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AUGUST 1959

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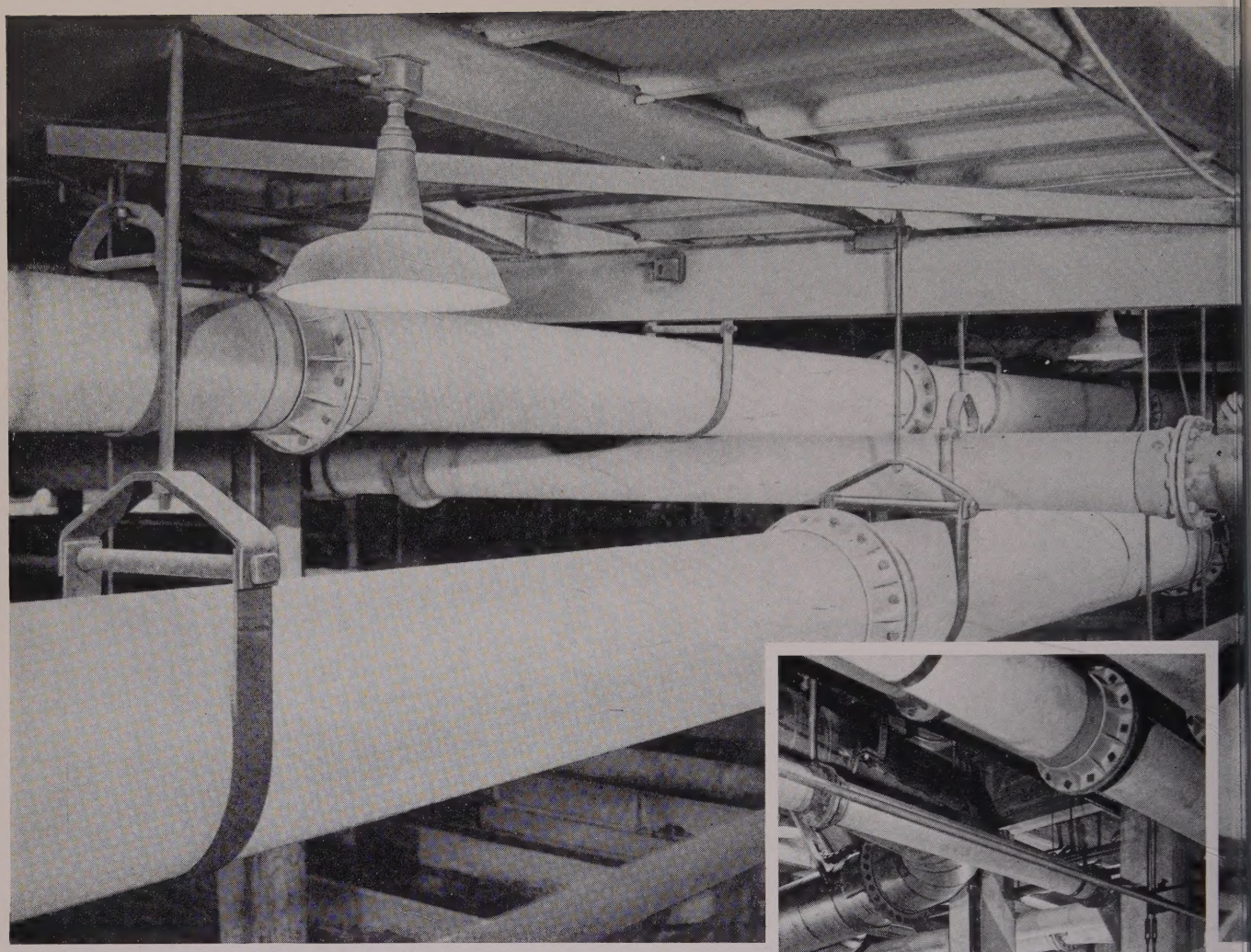
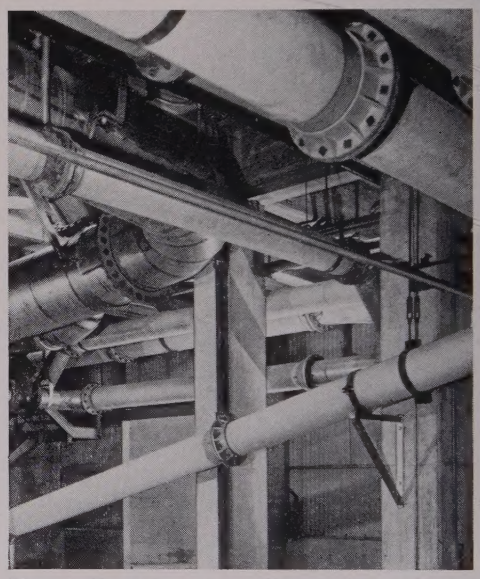


Transite Pipe performs nine different services in the St. Regis Company's Jacksonville Plant.



Transite line is from new mill washed stock chest to old mill washed stock chest.

Transite Pipe helps St. Regis work giant new "Seminole Chief" at full capacity!

Chief Engineer, L. C. Crowder, tells of experience with Transite . . . how its flow capacity and "cleanliness" determined its selection

Almost by the day, we see new reports on the added economy and performance that Transite® Pipe brings to water and stock lines. One such report comes to us from the St. Regis Company's Jacksonville Plant:

"When we recently installed the Seminole Chief, one of the largest capacity machines in the industry," says Mr. Crowder, Chief Engineer, Pulp & Paper Division, "production jumped from 300 to 1300 tons per day. And water capacity and stock cleanliness became more important than ever.

"Six years' experience with Transite Pipe told us it would do the job. It has an exceptionally smooth interior surface that offers minimum frictional resistance to the flow of liquids. Of equal importance, it is immune to tuberculation and is resistant to sliming and bacterial growths.

"For all those reasons we chose Transite Pipe for our entire system. Carrying water and stock in nine different types of lines, Transite helps us maintain an even and continual flow rate . . . with required stock cleanliness."

Proven installation economy, maintenance savings and resistance to stock build-up—make Transite Pipe well worth your investigation. Meanwhile, let us send you copies of TR-113A, a 24-page illustrated brochure and TR-180A, the Transite installation guide for process systems. Send for them today. Address Johns-Manville, Box 147A, New York 16, N.Y.

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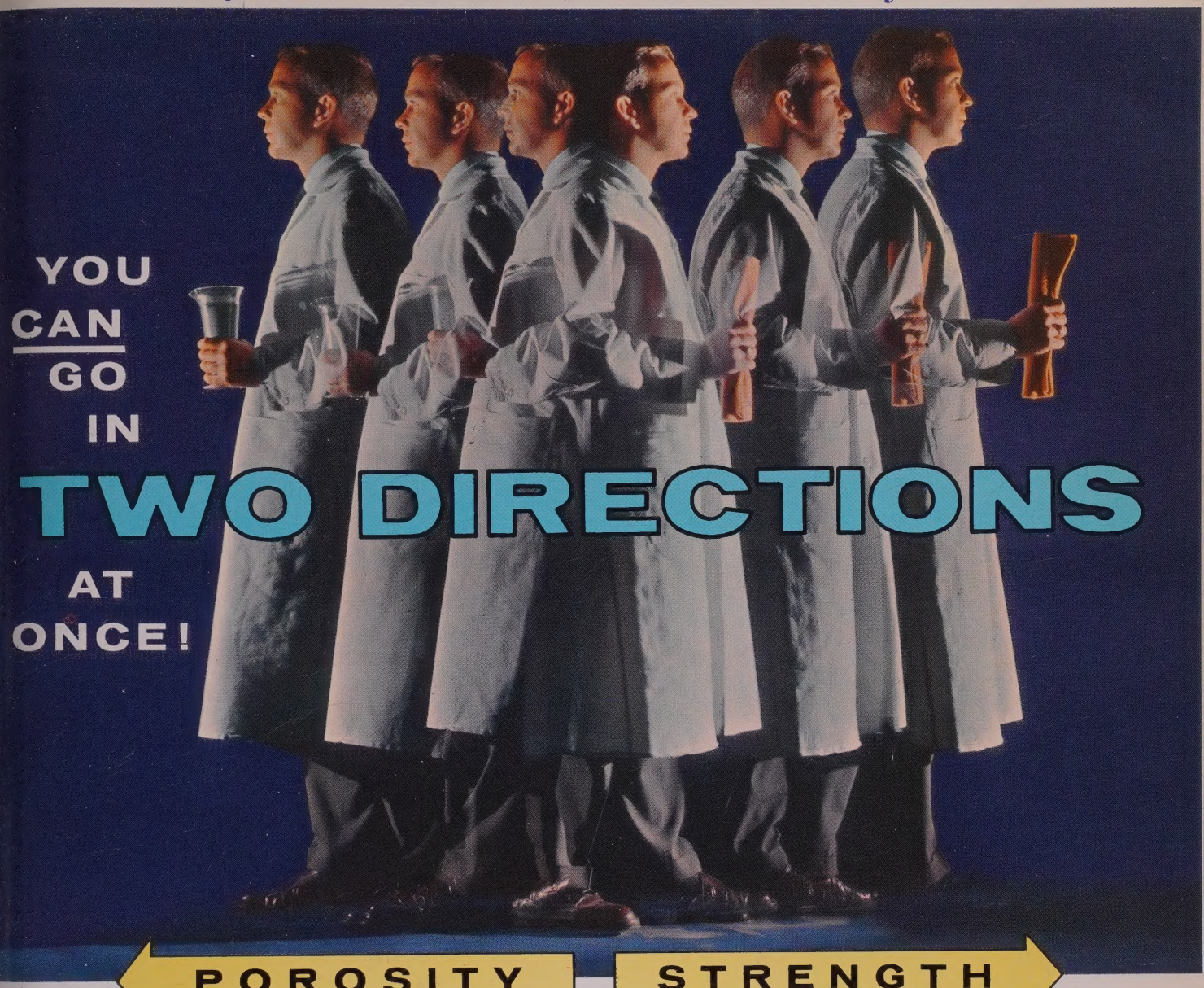
with Albany Felt chemical treatments and synthetics . . .



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At last, the ideal balance between *strength* and *drainage* in felt design can be obtained. With Albany's patented synthetic content design, greater resistance to abrasion is provided *and* Albany's special chemical treatments reduce the natural tendency of the synthetic yarns to be non-absorbent. Thus, two opposite aims can be reached simultaneously.

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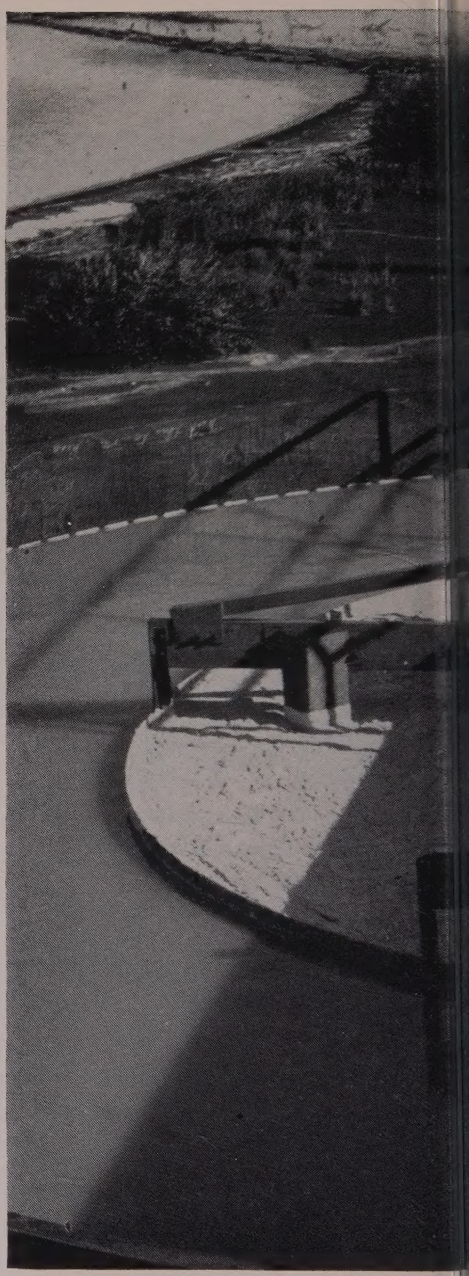
The Technical Articles are in accord with the recommendations of the Division of Pulp, Paper, and Board of the International Union of Pure and Applied Chemistry.

Marathon again shows the way in

MAINTAINING HEALTHY PUBLIC WATERS



For years, Marathon, a Division of American Can Company, has been a leader in improvement of public waters. Spent sulfite liquor from pulpmaking operations is processed into profitable, useful chemicals.

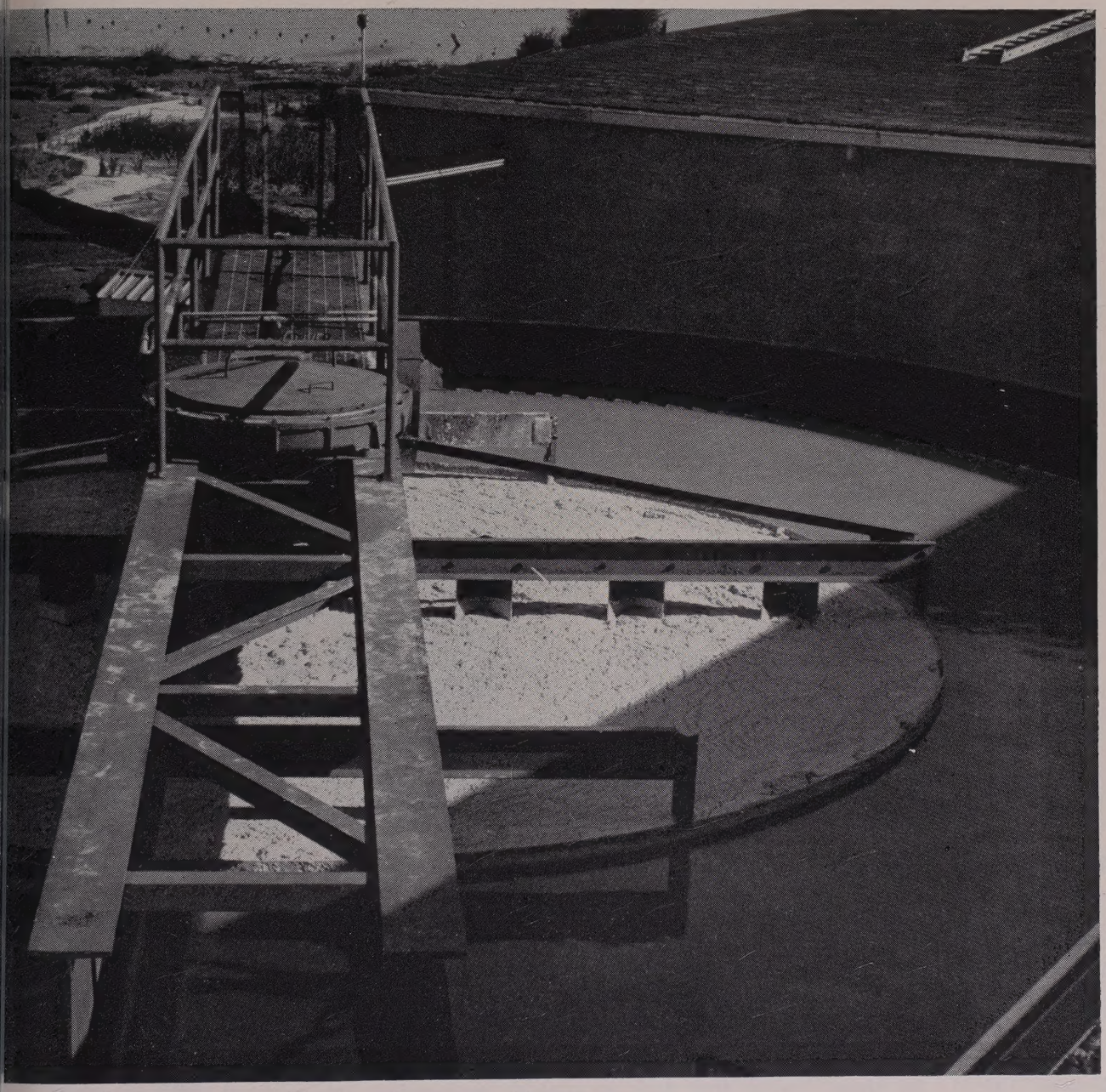
Now, applying another type of improvement of public waters, Marathon has installed equipment which clarifies paper mill liquids for re-use in its paper mill at Ashland, Wis.

White water from the washer is treated in the 40′ x 14′ Dorrco Clariflocculator shown in the photograph. The flow amounts to 725 gpm and contains approximately 728 ppm of suspended solids. 100 ppm of CaO and 25 ppm of SiO_2 are used as flocculants. Efficiency of operation is shown by the fact that overflow from the unit contains only some 28 ppm and the underflow is discharged at 1% to 3% solids. The reclaimed clarifier effluent is cycled to the hydropulper.

Benefits in dollars and cents resulting from re-use of the clarified water include considerable fuel savings, since the water temperature is about 90°F., compared with 34°F. for lake water.

Equipment for profitable waste treatment processes is a Dorr-Oliver specialty. For information, just drop us a line . . . or better still, have one of our specialists call to discuss your problems and suggest the most efficient solution. No obligation, of course.

The Dorrco Clariflocculator is a combination unit which carries out the unit operations of flocculation and clarification in two compartments within a single tank. The unit makes possible high suspended solids removal in many applications where the flocculation process is required for efficient operation. Photo shows installation at the Marathon plant at Ashland, Wis.



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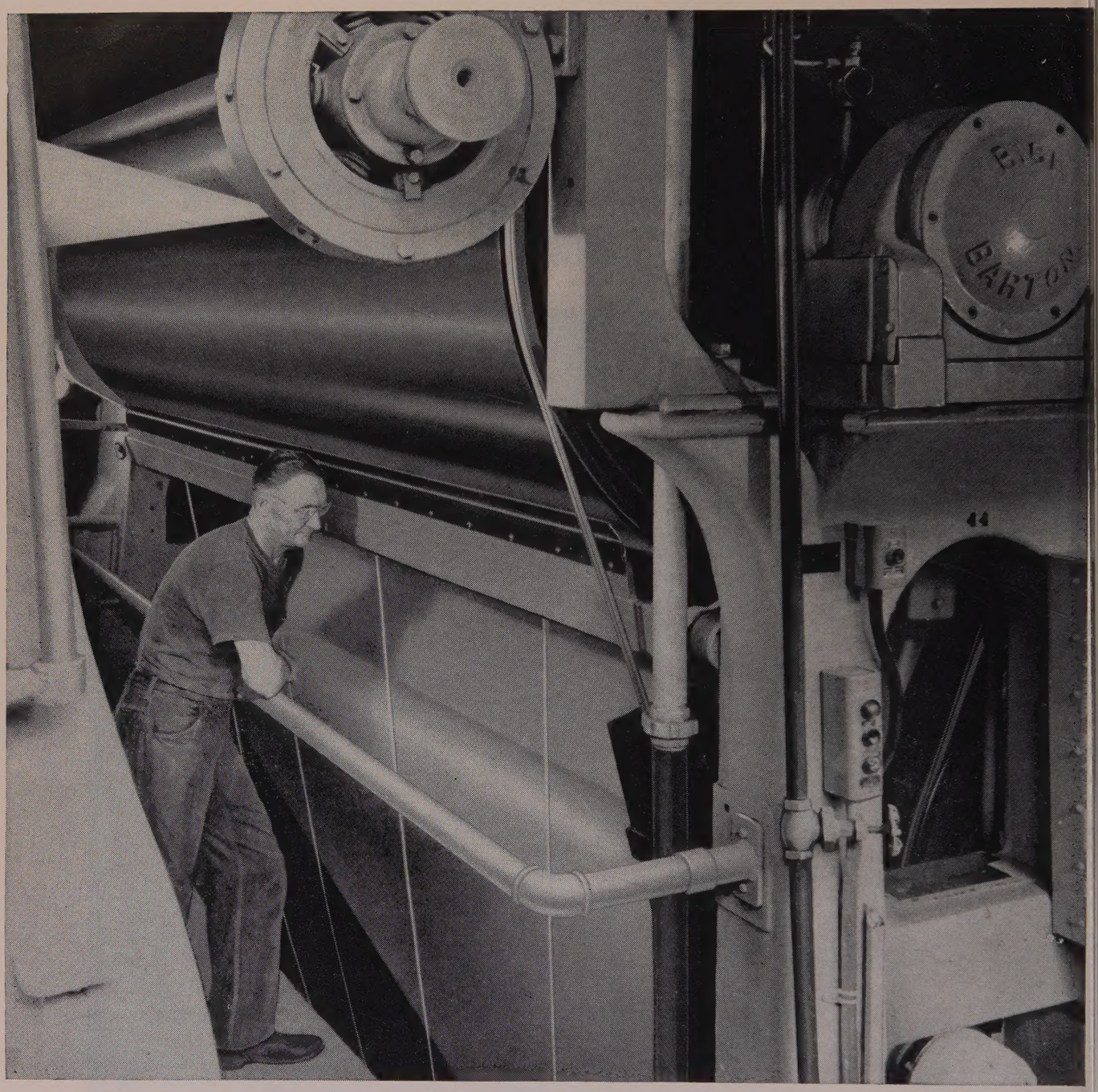

RECORD HOLDER—Consolidated Enamel Printing Papers are widely utilized for magazine printing and other applications requiring a paper stock with a high degree of strength and surface uniformity. This #4 Machine at the Biron Division of the Consolidated Water Power & Paper Company of Wisconsin Rapids is capable of operating at speeds between 1700 and 1750 feet per minute. It is believed to hold the world's record for high speed enamel book paper machine operation. Consolidated uses for this #4 Machine, Siamese 135's—Mount Vernon Dryer Felts.

This is another example of how fabrics made by Mount Vernon Mills, Inc. and the industries they serve, are serving America. Mount Vernon engineers and its laboratory facilities are available to help you in the development of any new fabric or in the application of those already available.

PRE-STRETCHED – All Mount Vernon dryer felts are available pre-stretched and pre-shrunk, with or without clipper seams.

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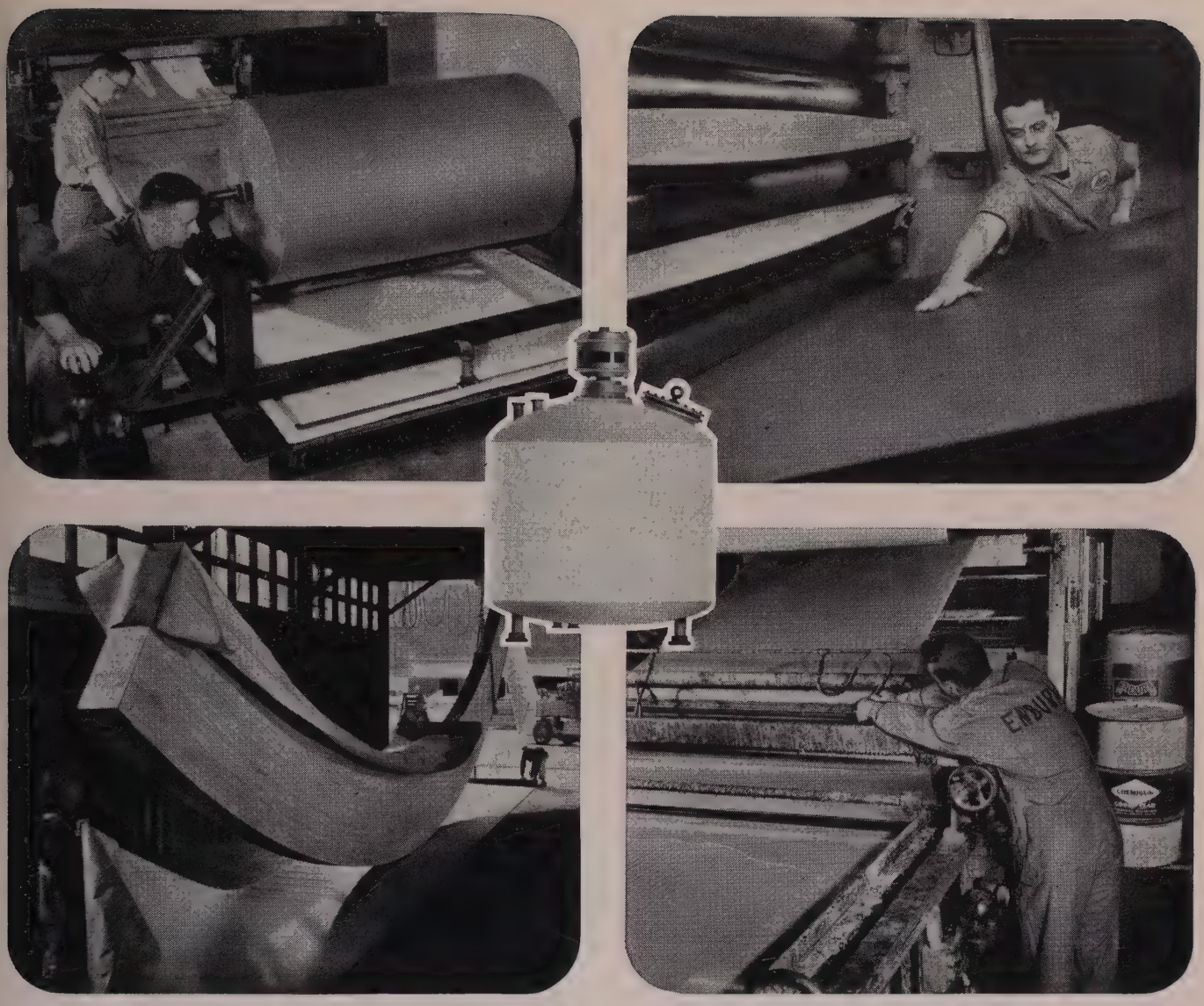


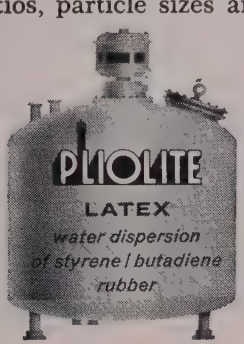
For quality papers—four quality latices!

Major improvements in paper are rolling out of the paper industry at a constantly increasing rate. Papers with *special* qualities are being developed for *special* needs. As this trend continues, manufacturers are becoming more and more selective about latices. Quality is vital. And the latex chosen must be *exactly right* for the specific type of paper being made.

To meet this need, Goodyear offers four basic latices: PLIOLITE *Latex* in two forms (as a rubber or resin dispersion), PLIOVIC *Latex* (dispersion of vinyl copolymer resin) and CHEMIGUM *Latex* (dispersion of nitrile rubber). All are available in a broad range of monomer ratios, particle sizes and types of stabilization. They can be used alone—or in combination with each other—or as modifiers of your present materials.

Among the benefits you can expect from these latices are: better body, drape, strength and dimensional stability—improved flexibility and softness—exceptional resistance to aging—and outstanding wear qualities.

You can also expect the finest in technical assistance when you work with a Goodyear latex. Contact your Goodyear Chemical Division Representative for all the facts. Or write for details—including latest *Tech Book Bulletins*—to Goodyear, Chemical Division, Dept. H-9432, Akron 16, Ohio.



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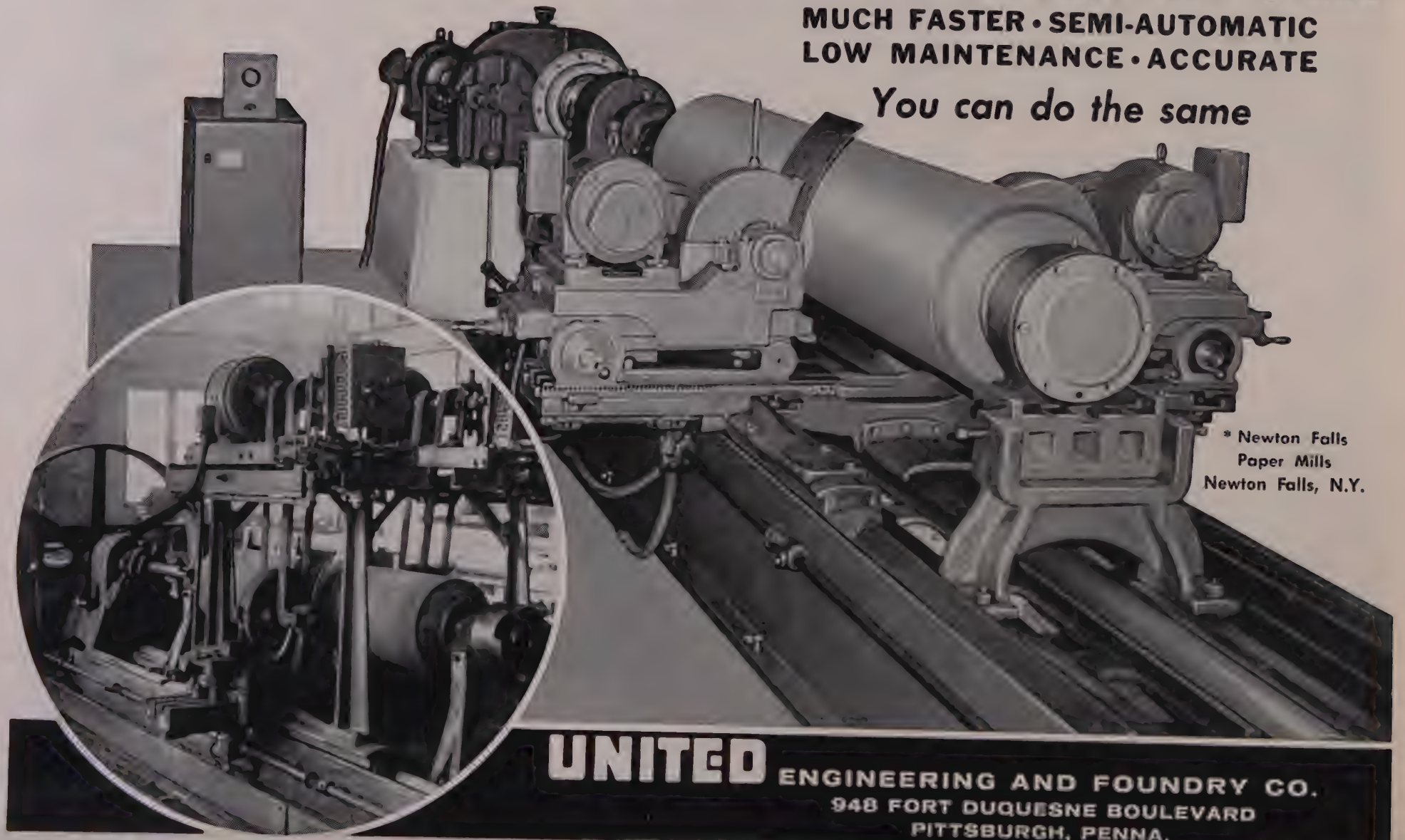

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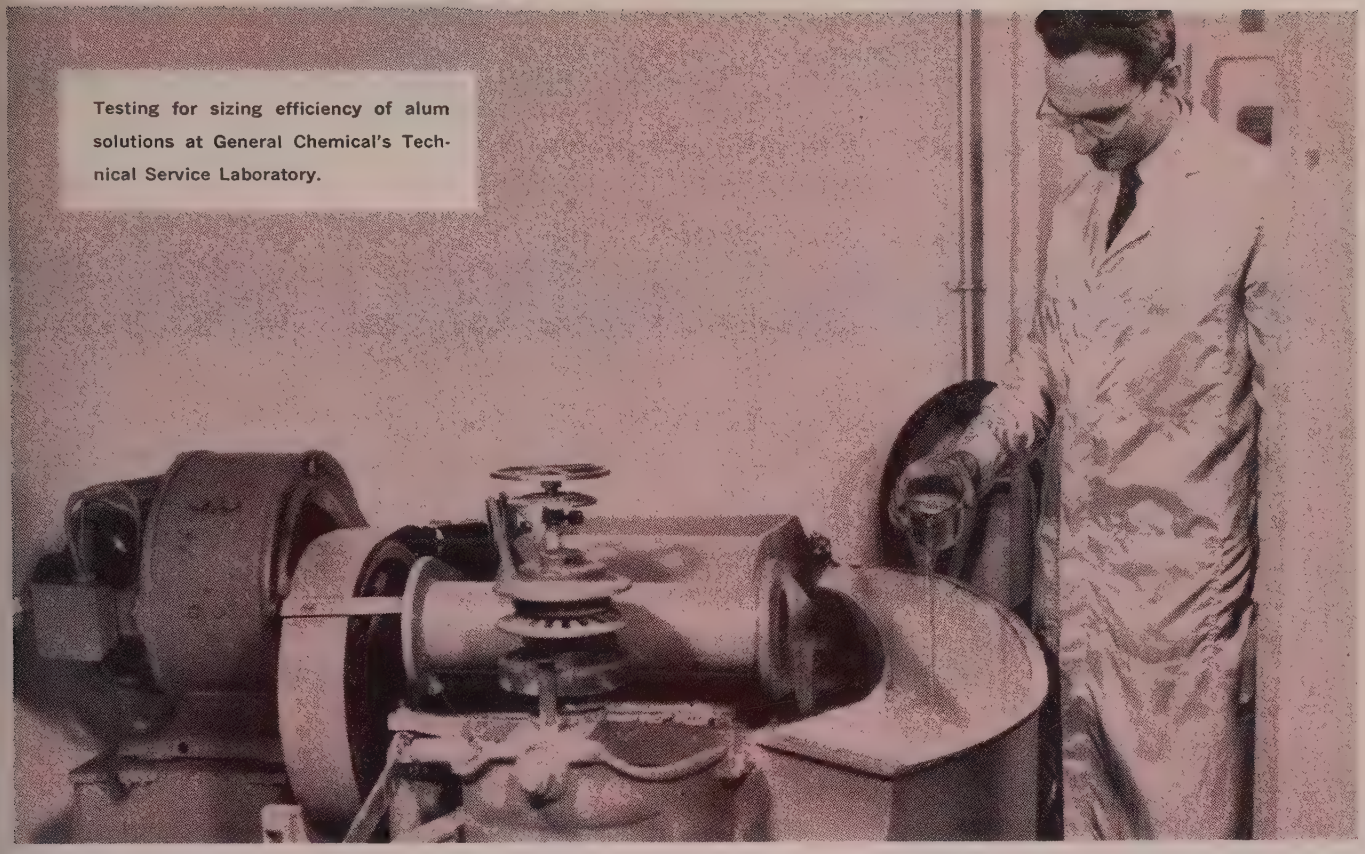

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Another difference in GENERAL CHEMICAL ALUM is TECHNICAL SERVICE

As the country's primary producer of alum, General Chemical is constantly helping customers solve technical problems involving the use of aluminum sulfate. Results? Improved efficiency and reduced operating costs for them.

Here are some of the services our Technical Service Department offers you:

- Supplying basic information helpful in planning design and installation of storing, pumping, metering and feeding facilities.
- Suggesting improvements to eliminate existing storing and handling problems.
- Providing chemists and operators with physical and chemical data necessary for the most effective use of alum.
- Assisting in laboratory tests and plant trials.
- Running check analyses in our own laboratories.

In the paper mill, our specialists advise on the most efficient use of aluminum sulfate for a particular mill's requirements. They can provide assistance on the important conversion from dry to liquid alum, and furnish guidance on the proper design of new installations and selection of materials to avoid handling or maintenance problems. In many instances, chemical problems arise in operations which are not necessarily related to alum. At such times, General's Technical Service continues to offer helpful advice and lend assistance whenever possible.

This kind of Technical Service is one of the reasons why General Chemical is a good company to do business with for *your* mill's alum requirements. We will welcome the opportunity to serve you.

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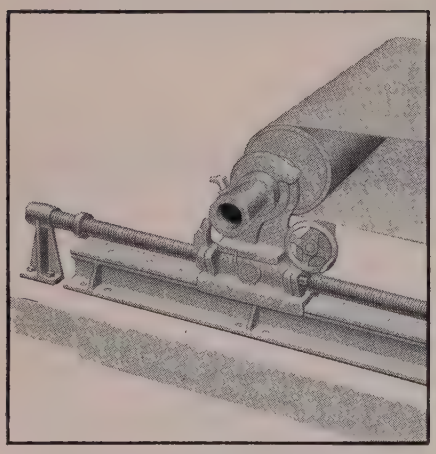
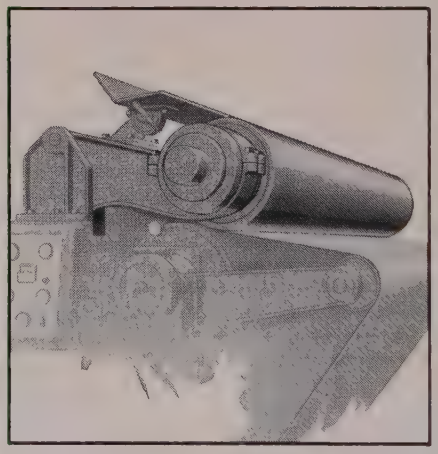


Felt stretch under positive control?

Heavy-duty Beloit felt-stretchers combined with felt tension indicators provide positive control of felt tension and stretch. Optimum felt stretch can be maintained from shift to shift, day to day. Felt life and drainage can be increased—felt guiding is more positive. Seam-straighteners are an integral part of Beloit felt-stretchers. Air motor operators are available for both stretchers and seam-straighteners.

Press crowns a problem?

If so, consider stiffened, rugged Beloit press rolls. Bolted heads coupled with Beloit heavy-wall design result in uniform deflection as opposed to press rolls with cast heads. Heavy-duty antifriction bearings are protected from loss of lubricant or entrance of moisture. Call on Beloit for grey iron, ductile iron, or granite press rolls for dependable service at press, size press, breaker, or wringer roll positions.



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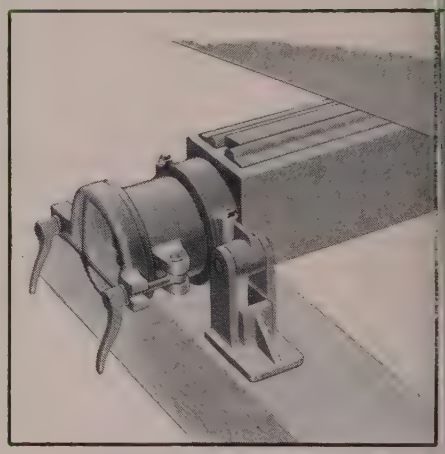


Felts filling up?

Many mills have found Beloit felt suction boxes a profitable answer to longer felt life and improved sheet quality. A Beloit felt suction box and shower arrangement provides full-width continuous cleaning—keeps felts clean and open. An adjustable slot width supplies just the right amount of vacuum for the specific application. A low-cost addition that can keep felts cleaner—longer.

PROVED BELOIT UNITS FOR THE PRESS SECTION. FELT ROLLS
PAPER ROLLS • SAVEALLS • PRESS DOCTORS • DIAPHRAGM
LOADING UNITS • SHOWER ARRANGEMENTS • MARKING EQUIPMENT

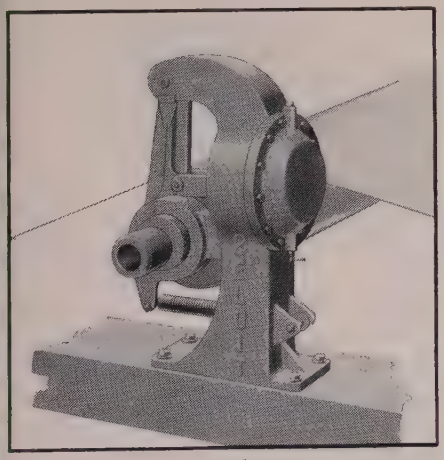
ONE OF A SERIES SHOWING TYPICAL BELOIT SOLUTIONS TO COMMON MILL PROBLEMS

factor in your production picture?

Modernize your press section with proved Beloit units. Components for the press section of your paper machine shown here have proved to be of special value in increasing output, improving quality, reducing machine downtime, and cutting operating costs. A Beloit press arrangement is available for every paper machine application. Let Beloit sales engineers show you the best press design for your machine. Their suggestions can pave the way to greater profits.

Felts running off periodically?

A felt lost due to guide failure can cost more than a new Beloit air diaphragm felt guide. Why not modernize with a low-cost Beloit automatic felt guide now? The patented Beloit air diaphragm guide moves the guide roll smoothly and efficiently. Its rate of response is independent of felt speed —its outside power supply reduces felt edge wear. The entire mechanism is simple, foolproof, rugged—no small parts subject to easy damage. Models available for every press application.



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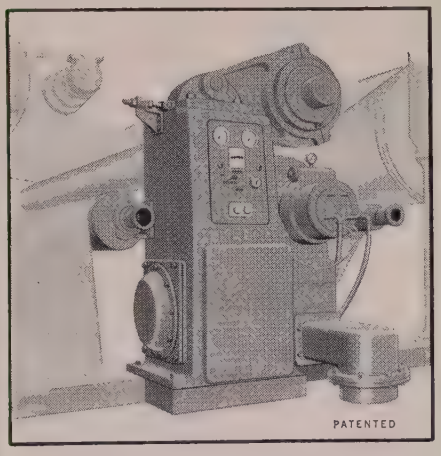

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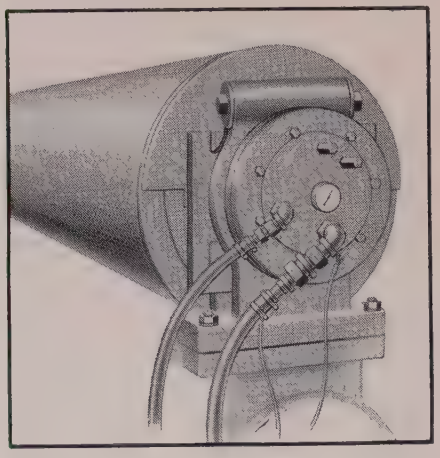
Heavyweight sheets a problem?

The Beloit hot press is doing a fine job on machines running heavyweight grades. The hot press dewaters the sheet after it has been raised in temperature, resulting in greater water removal and a dryer sheet to the main dryer section. The Beloit hot press arrangement may be employed as a plain hot press or a suction hot press depending upon your requirements. When used as a suction press, the hot press employs the unique Beloit air-bleed principle.

Speed limited by drying capacity?

Get maximum sheet dewatering at minimum cost with Beloit suction rolls. Machines can run better at increased speeds and with improved operating efficiency—and a dryer sheet entering the dryer section. There's a Beloit suction roll for every press section application: suction press, suction pick-up, suction pressure, suction transfer, suction felt, suction wringer, or suction hot press.



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Second Supplemental Report—June, 1959—to Pulp, Paper, and Board Supply-Demand Report*

SUBMITTED TO THE SUBCOMMITTEE ON COMMERCE AND FINANCE OF THE HOUSE INTERSTATE AND FOREIGN COMMERCE COMMITTEE IN JUNE, 1957

THIS is the second supplemental study to the basic report, "Pulp, Paper, and Board Supply-Demand," prepared by the Business and Defense Services Administration in early 1957. A year ago, in June, 1958, the first supplemental report was published.

In the basic 1957 report, it was expressly stated: "*This report does not attempt to forecast definite supply or demand for any particular year.*" As clearly outlined in the basic report, the estimates of future domestic demand and production are statistical projections based upon specific assumptions.

As is generally known, the years 1957 and 1958 witnessed a dip in the National economy which was marked, in particular, by a decline in industrial production starting in the latter half of 1957. This slackening in economic activity, affecting most industries, continued until the spring of 1958, when an upturn became evident. An important factor contributing to the 1957–58 business decline was the liquidation of business inventories, accompanied by falling sales. Variations in the Nation's economic activity from the long-term average annual growth trend have always occurred and must continue to be recognized.

These developments in national economic activity affected the paper industry, resulting in a slackening in paper and board production in 1957 and 1958 compared to 1956. Thus, actual 1958 output was materially below the statistically projected level for 1958, as set forth in the basic report.

As analyzed in this current study, it is possible that the projections of demand and production for 1960 may be realized provided the present vigorous recovery in economic activity continues through 1960, when a return to the long-term national economic growth trend, as projected in the basic report, could be expected. This trend was based upon stated assumptions, a major one being that economic activity would reflect a full-employment situation. Provided these assumptions materialize, the levels of projected paper and board demand and production for 1965 may also be attained. Such long-term projections for specific industries and products are always contingent upon any important changes in major market outlets and demand as could be affected, for example, by competitive products from other industries and changes in consumer preferences.

A complete reappraisal of world newsprint demand and supply, by continents and individual countries, through to 1960, is included in this supplemental study to meet the particular interests of the Subcommittee on Commerce and Finance.

This report was prepared under the technical direction of W. LeRoy Neubrech, assistant director for Pulp, Paper, and Paperboard, Forest Products Division, Business and Defense Services Administration. James M. Owens, director of the Forest Products Division, directed administrative procedure and policy. Staff members contributing to this study were: John J. Bartosiewicz, program executive for paperboard, who prepared the sections on world newsprint, woodpulp, and other fibrous materials; and John R. Mutzabaugh, program executive for converted products, who prepared the sections on paper and board. Horace Hart, director, and Miss Anne Jacks, program executive for Books and Magazines, Printing and Publishing Industries Division, prepared the material on factors affecting domestic demand for newsprint and other printing papers.

I. INTRODUCTION AND SUMMARY

This second supplemental study to the basic report, "Pulp, Paper and Board Supply-Demand," has been prepared because of continuing interest of the Subcommittee on Commerce and Finance of the Committee on Interstate and Foreign Commerce, House of Representatives, in the paper supply situation, especially newsprint.

The basic report was printed as House Report No. 573, 85th Congress, 1st Session, dated June 17, 1957. The first supplemental study, "Pulp, Paper, and Board Supply-Demand—Newsprint Outlook," was printed as House Report No. 1868, dated June 10, 1958.

Purpose of Study

The 1956 and 1957 data appearing in the basic report and the first supplemental report have been revised in this study, largely on the basis of the latest corrected Census figures on production, imports, and exports. Preliminary 1958 data on production, imports, and exports, as well as calculations on apparent consumption for 1958, have also been included in this study.

To meet the particular interests of the Committee, a new world survey of newsprint supply and demand was conducted with the cooperation of the Foreign Service offices in 63 countries. Revised data were prepared for 1957 through 1960 and have been incorporated in this study.

Assumptions, Terminology, and Qualifications

The projections of domestic demand and production, exports, and imports for 1960 and 1965, which are

* The tables have been omitted in this presentation and reference is made to the complete report issued by the Business and Defense Services Administration, U. S. Department of Commerce, Washington, D. C.

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included in the statistical tables appearing herein, are based on the definitions and explanations relating to assumptions, terminology, and qualifications that appear in the 1957 basic report. *It is important to bear in mind that the future domestic demand figures were derived from economic correlation projections and do not represent precise forecasts for any particular year.*

Summary

United States paper and board production in 1958 totaled 30.8 million tons, a gain of 119,000 tons over 1957 but a decline of 644,000 tons below the peak year of 1956.

The slackening in domestic paper and board production in 1957 and 1958 as compared to 1956 resulted in actual 1958 output being about 3.2 million tons (or 9%) below the projected production of 34.0 million for 1958, as estimated in the basic report about 2 years ago. Although the projections did not materialize for 1958, it is possible, on the basis of historical performance and current trends, for paper and board production to meet the basic report's estimates for both 1960 and 1965.

Production of paper and board in the first quarter of 1959 recorded a gain of 10% over the same period of 1958. Preliminary estimates for the first 6 months of 1959 point to a production of about 16.9 million tons, or 13% over the first half of 1958. Assuming a continuation of this level of output for the last 6 months of 1959, a new annual record of 33.8 million tons would be achieved, or close to 10% over 1958.

The projected paper and board production of 36.5 million tons for 1960 would require an annual rate of growth of 8.9% in both 1959 and 1960 over the year 1958. Though this is much larger than the long-term average annual growth, there have been historic periods when annual gains of that magnitude have been achieved.

The projected paper and board production of 43.8 million tons for 1965 would require an annual rate of growth of 5.2% over 1958, compared with a long-term annual average of 3.5%.

Newsprint production in the United States in 1958 was 1,723,000 tons, compared with 1,797,000 tons in 1957 and 1,620,000 tons in 1956. Imports of newsprint in 1958 amounted to 4,883,000 tons, contrasted with 5,221,000 tons in 1957 and 5,569,000 tons in 1956. United States exports of newsprint were 127,000 tons in 1958, compared with 174,000 tons in 1957 and 152,000 in 1956.

With the exception of newsprint, United States paper and board production closely approximates apparent consumption because exports and imports are comparatively small and to a degree tend to offset each other. Newsprint imports, however, are significant and account for about 15% of total consumption of all grades of paper and board. For newsprint alone, 1958 imports represented about 75% of consumption.

Total apparent United States consumption of paper and board in 1958 was 35.2 million tons. This represents a slight decrease from 1957, when consumption was 35.3 million tons, but a substantial decline from the peak year 1956 when consumption was 36.3 million tons. Actual 1956 total consumption was probably less than indicated statistically because of inventory accumulation, but in 1957 actual consumption was probably somewhat larger than shown because of inventory liquidation.

United States newsprint consumption (adjusted for inventory changes) in 1958 amounted to 6,501,000 tons, compared with 6,771,000 tons in 1957 and 6,807,000 in 1956, according to Department of Commerce statistics. For 1959, the United States consumption is currently estimated at 7,000,000 tons, a revision from the estimate of 7,180,000 tons made about 2 years ago.

The revised estimate of world newsprint production potential in 1958 of 15,782,000 tons exceeds estimated demand by 1,962,000 tons. For 1957, the revised world production potential of 14,793,000 tons exceeded actual consumption by 913,000 tons. World survey estimates place the production potential for 1960 at 17,388,000 tons, compared with estimated demand of 15,239,000 tons. This would indicate a surplus capacity of 2,149,000 tons. Depending upon market conditions, some of this world production capacity reported as available for newsprint may be diverted to production of other grades, especially groundwood printing papers, as has frequently occurred historically.

Apparent United States consumption of printing papers in 1958 was 4,016,000 tons, contrasted with 4,043,000 in 1957, and 4,314,000 in 1956.

The trend toward increased total United States annual capacity to produce paper and board continues. On the "historic basis" of measurement, annual capacity in 1958 is reported at 35.7 million tons. This compares with 31.7 million tons in 1956. By 1961, a capacity of 39.0 million tons is anticipated. Capacity in 1958, on the "maximum bases" of measurement, was 38.3 million tons, compared with 34.1 million tons in 1956. By 1961, this capacity is expected to total 41.9 million tons.

United States annual newsprint production capacity, reported only on a prevailing operating schedule basis, was 2,100,000 tons in 1958 compared with 1,625,000 tons in 1956. By 1960 the expected capacity will be 2,488,000 tons. On the basis of these estimates, domestic newsprint capacity would increase by 863,000 tons between 1956 and 1960, a gain of over 50%.

The lower level of 1958 and 1957 woodpulp production and consumption compared to the peak year of 1956 reflects the slackening in paper and board production during this period. Total United States production of woodpulp in 1958 was 21.7 million tons, compared with 21.8 million tons in 1957 and 22.1 million tons in 1956.

Imports of woodpulp in 1958 and 1957 totaled 2.1 million tons annually as against 2.3 million tons in 1956. Exports were 515,000 tons in 1958; 622,000 tons in 1957; and 525,000 tons in 1956.

Actual United States consumption of woodpulp in 1958 totaled 23.3 million tons, the same as in 1957, and 23.9 million tons in 1956.

The growth in woodpulp capacity facilities approximately parallels the upward trend in paper and board production facilities. United States woodpulp capacity for 1958 is reported at 27.7 million tons, compared with 24.2 million tons in 1956. The expected capacity by 1961 is 28.9 million tons.

Pulpwood consumption by United States pulp

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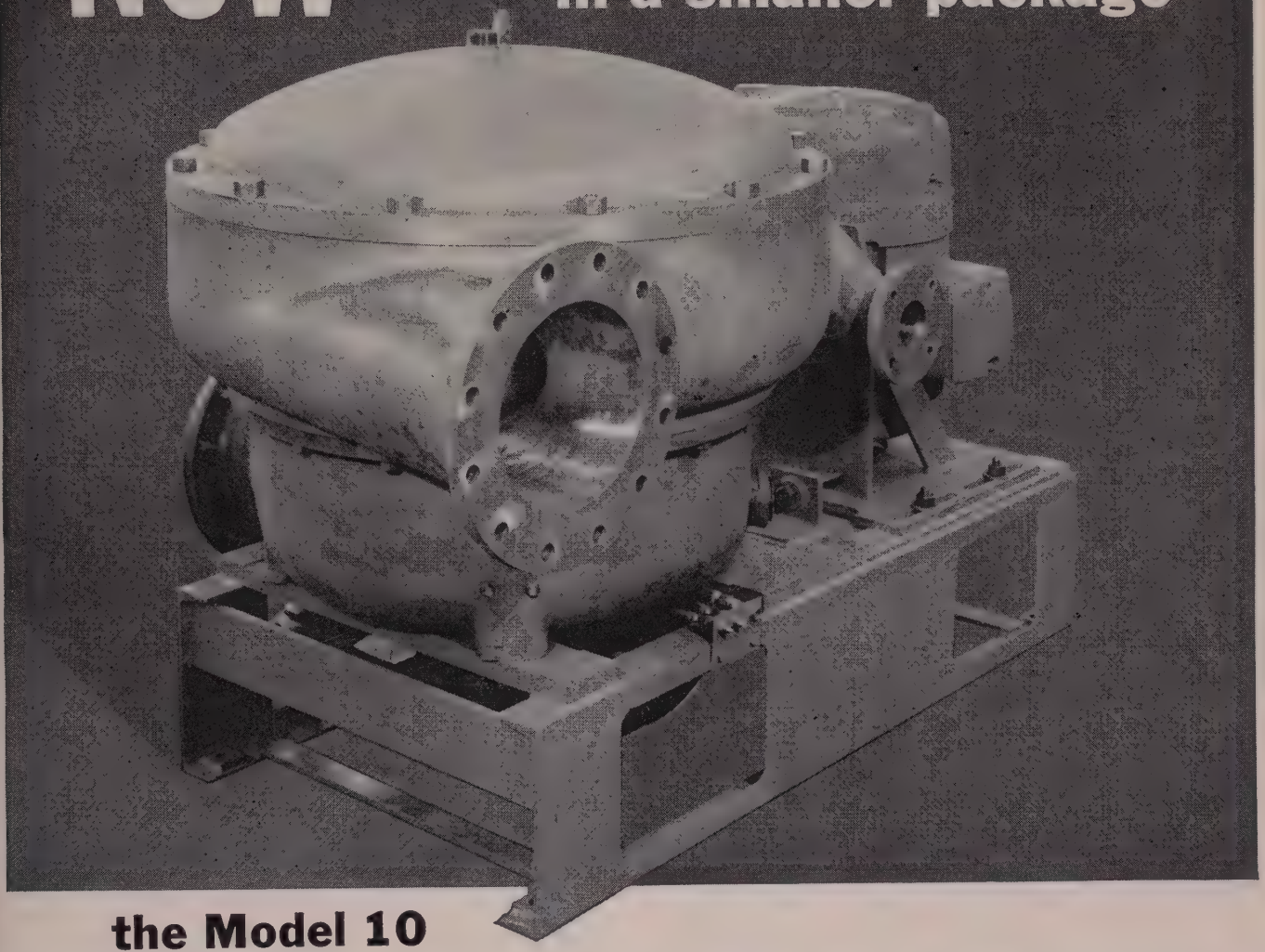

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mills in 1958 totaled 35.2 million cords, a decline from the 35.7 million cords used annually in 1957 and 1956. In recent years, the utilization of hardwoods, largely second growth, has increased materially. In 1958 hardwood pulpwood usage was more than 6.0 million cords, compared with 2.5 million cords in 1947.

Utilization of waste paper, frequently called paper stock, in 1958 was 8.7 million tons, registering an increase from the 8.5 million tons consumed in 1957 but a decline from the 8.8 million tons in 1956.

II. UNITED STATES PAPER AND BOARD PRODUCTION AND APPARENT CONSUMPTION

The recession in the over-all economy of the United States in 1957 and 1958 was the major factor causing a slackening in domestic production and consumption of paper and board. Production in 1958 was approximately the same as in 1957 and about 2% below 1956. With the long-term growth trend temporarily broken, 1958 tonnage output as projected in the basic Pulp, Paper, and Board Supply-Demand Report of 1957 was not met. However, it is possible, on the basis of historical performance and current trends and assuming, of course, a full-employment economy, for paper and board production to meet the basic report's estimates for both 1960 and 1965.

Actual 1958 production of paper and board of 30.8 million tons was 9% below the projected 34 million tons. All of the major segments of total paper and board were also below the estimates for 1958. Total paper production at 13.5 million tons was off 9%, as was total paperboard output at 14.3 million tons. Total building paper and board production of 3 million tons was 14% below the projected output for 1958.

No projections were made for 1959 in the basic report, but paper and board production is expected to increase over 1958 at a substantially higher rate than the 3.5% average annual growth rate established in the basic report as normal for paper and board over the last 30 years. Production for the first 6 months of 1959 is estimated at 16.9 million tons compared with 15.0 million tons in 1958. Provided production is maintained at this level for the remainder of the year, which as of early June appears most likely, tonnage output for 1959 should exceed 1958 by about 10%. This would place the paper and board industry in a better position than at any time since 1956, from which to meet 1960 and 1965 projections.

Though the tonnage estimated for 1958 was not achieved, it is possible, on the basis of historical trends, for production of paper and board to attain the necessary average annual rate of increase required to meet both the 1960 and 1965 projections. Production has varied considerably from year to year in the past. Large increases over year-earlier output usually were achieved following a year or two of moderation in the economy, such as occurred in 1957 and 1958.

For three of the last 10 years, production of total paper and board attained year-to-year increases in excess of the average annual rates of increase required to meet the 1960 projections. The basic report estimated 1960 production of total paper and board at 36.5 million tons. An annual rate of increase of 8.9% for 1959 and 1960 is necessary to attain this tonnage. Production in 1950 increased 20% over year-earlier output; in 1953, 9%; and in 1955, 12%.

Annual rates of increase required for the major segments of total paper and board to meet the 1960 projections have also been attained in certain prior years. To meet 1960 estimates, paper production in 1959 and 1960 requires an average annual rate of growth of 8.5%, an increase which has occurred four times since 1949. For paperboard, the necessary 8.7% growth rate has been achieved three times in the last 10 years. The average annual rate of increase of 11.5% needed for total building paper and board to meet the 1960 projections has been attained twice in the 1949–58 period.

Average 1959–65 annual rates of increase necessary for paper and board production to meet the 1965 projections are closely in line with normal rates of output. For total paper and board, an increase of 5.2% is required; for total paper, 4.5%; total paperboard, 5.7%; and total building paper and board, 6.0%. Comparable or higher year–to–year increases were attained in 1950, 1951, 1953, 1955, and 1956.

In addition to the ability to achieve a high average annual rate of increase, exemplified historically, several existing trends are encouraging for the future of paper and board production.

Activity improved in late 1958 and early 1959 in those segments of the over-all economy to which paper and board output are closely aligned. Disposable personal income increased 5% for the first quarter of 1959 over the same period in 1958, while total industrial production rose 12% and nondurable goods production 11%.

The major markets for paper and board have been increasingly active. During the opening months of 1959, printing and publishing, which consumes 30% of paper and board output, showed successively increasing margins over last year's business. Production increases over year-earlier output were 2% for January, 4% for February, and 6% for March. About 46% of paper and board production is consumed in the manufacture of converted products, such as boxes, sanitary tissue, and food serving products. For the first quarter of 1959 over 1958, production of converted paper and board products increased 13%. Activity for 1959 is substantially above 1958 in the other major markets for paper and board, including the retail and wholesale trade, government, construction, and other industries.

Total apparent United States consumption of paper and board, with the exception of newsprint, is substantially the same volume as domestic production, because exports and imports, other than newsprint, are comparatively small and tend to offset each other. Therefore, consumption data are not separately analyzed. The United States trend in newsprint production and consumption is reviewed in Section VIII.

III. FACTORS AFFECTING NEWSPRINT AND PRINTING PAPER DOMESTIC DEMAND AND CONSUMPTION

Newsprint Review and Outlook

Apparent United States consumption of newsprint in 1958 was 6,501,000 tons, according to figures com-

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METASOL lowers production costs because it keeps machines clean and helps them deliver a finer product without loss of time. In many cases, periods between boil-outs can be extended three to four times.

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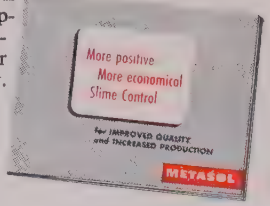

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piled from Census Bureau data on United States newsprint production, imports, and exports adjusted for changes in inventories as reported by trade associations. This was 277,000 tons, or 4.1%, less than 1957 consumption. The American Newspaper Publishers Association figure for 1958 consumption is 6,599,981 tons, a decrease of 3.9% from their 1957 figure.

This drop in newsprint consumption was almost entirely the result of the 1957–58 adjustment in the national economy. Now that the economic trend has been reversed, consumption has similarly improved, and at such a rate that the current 1959 consumption of newsprint is returning to almost the 1957 level. Apparent consumption for the first quarter of 1959 showed an increase of 6% over the same period for 1958.

To make a projection on an annual basis is always precarious; judging by current factors, the projection made in the 1957 estimate for 1959 consumption may have to be revised slightly downward, to not more than 7 million tons. However, the longer range projection for 1960 and beyond need not be revised at this time.

Circulation. In 1958, daily circulation remained stable at 57,418,311, as compared to 57,805,445 in 1957, a difference of 0.67% in single copy sales. Sunday paper circulation in 1958 was 46,965,686, substantially the same as 1957.

Newspaper Work Stoppages, 1951–58[a]

	Work stoppages started	*Daily newspapers involved*
1951	3	3
1952	12	17
1953	13	22
1954	7	8
1955	9	17
1956	14	23
1957	31	53
1958	38	62

[a] Includes Canadian newspapers.

The trend toward 7-cent and 10-cent daily single copy sales continues, and, according to a recent American Newspaper Publishers Association survey, daily newspapers selling at 5 cents represented 58.2% of the total, compared with 66% in 1958.

Any review of newspaper circulation in 1958 must consider the fact that 15 daily newspapers suspended publication, and 10 new ones were established, for a net loss of five daily newspapers. Of the 15 suspending publication, five discontinued publication completely; four merged with other papers, notably in the cities of Cincinnati and New Orleans; and six dailies became weeklies or semiweeklies.

Work stoppages in 1958 also had their effect on circulation. Though the U. S. Department of Labor reported the second lowest total number of strikes occurring in the United States since World War II, the newspaper publishing industry had its second highest number. In 1958, 36 work stoppages affected 60 daily newspapers in the United States, compared with 31 work stoppages against 53 dailies in 1957.

It is surprising that, despite all these adverse factors—strikes, mergers, discontinuances of papers, single-copy price increases—circulation did as well as it did.

Geographically, circulation in the Northeast decreased slightly; the North Central dailies remained stable; a slight increase occurred in the South; and the West registered healthy increases. The suburban newspapers continue to grow, perhaps at the expense of the large metropolitan dailies.

Circulation is only slightly influenced by consumer economics. A major factor in circulation growth is population increase. Though an anticipated normal growth of 1% in circulation can be anticipated in 1959, in the years immediately ahead circulation should increase sharply as a greatly increased number of youths enter the newspaper "buying" age.

Advertising. In 1958, total advertising for newspapers, according to the Bureau of Advertising (a trade association), was valued at $3144 million, a decline of 4.2% from 1957.

So far in 1959, according to Media Records, Inc., total advertising linage in 52 index cities (representing 80% of newspaper advertising dollars) is 2.1% ahead of the first quarter of 1958. Dollar volume gains will exceed this percentage because of rate changes. As the year continues and the economy improves, newspaper advertising is expected to pick up more rapidly. Local advertising, representing approximately 60% of the total dollar revenue, is expected to set an all time high for 1959, probably 5 to 6% above 1958. Classified advertising, representing approximately 20% of dollar income, has so far shown an 8.6% increase over 1958.

An expanded economy means more job opportunities and more help wanted classified advertising. Such advertisements in March, 1959, increased 24% over the preceding month and 39% over March, 1958, according to the report of B. K. Davis & Bros. Advertising Service. Activity in help wanted ads has been a good indicator of the future course of the economy.

National advertising, representing about 20% of the total, has been increasing more slowly, perhaps owing partially to the flexibility of newspaper advertising, as compared to TV advertising. In an economic squeeze, it is far easier to curtail newspaper advertising than TV because of the nature of the contract agreements. This is an advantage to the advertiser, but a disadvantage to the publisher. The big question in national newspaper advertising will be the rate of economic recovery in consumer durable goods industries, which are large users of such advertising. Currently, it appears that 1959 will be one of the best years ever for these industries. Recent joint efforts by automobile manufacturers, dealers, and newspapers have shown very encouraging results in auto sales.

Business, in general, is increasing ahead of advertising expenditures. Although advertising continued to be used at a constant rate as the economy was slowing down, now the economy is outstripping current advertising expenditures, which should undoubtedly result in increased advertising to catch up with normal spending ratios of advertising to sales.

A noteworthy development is that some large variety store retailers have only recently entered the field of newspaper advertising. One such company increased their advertising linage from 400,000 in 1956 to almost 10 million in 1958. According to "Newsprint Facts," published by the Newsprint Information Committee,

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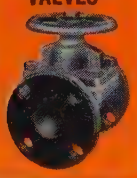

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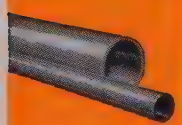

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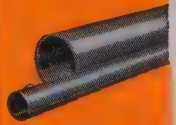

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newspapers stand to gain at least $25 million in new business from the supermarket industry in 1959. Furthermore, a concerted campaign to supplement normal efforts to sell newspapers as an advertising medium, sponsored both by the Bureau of Advertising and the American Newspaper Publishers Association, is under way. If successful this joint industry effort should help newspapers to obtain more than their normal rate of recovery of advertising.

Summary. The year 1959 will see a resumed uptrend in newspaper circulation and advertising. The decline of the past 2 years was due entirely to changed economic conditions rather than any fundamental change in the importance of daily or weekly newspapers. No foreseeable reason exists why newsprint consumption should not continue its growth as previously projected for long-range purposes. However, a 1959 consumption estimate of not more than 7 million tons seems more realistic than the original projection; on the other hand this downward adjustment of only 180,000 tons could easily be reversed by any slight increase in the present rate of economic upturn.

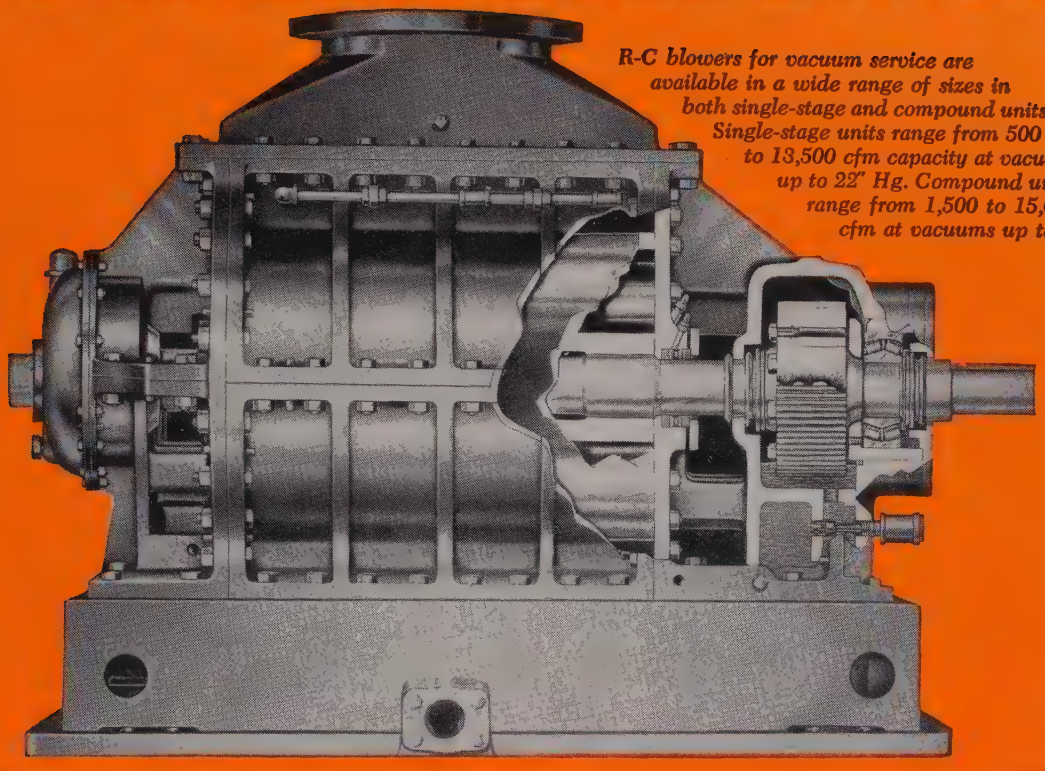
Consumption of Printing and Fine Papers by the Printing and Publishing Industries

The absence of comprehensive annual data on the tonnage of printing and fine papers used by the printing and publishing industries makes year-to-year analyses of trends in consumption difficult. Because the industries are major users of printing papers and account for a significant portion of fine-paper consumption, changes in total apparent consumption of these grade groups suggest proportionate changes in tonnages going into books, periodicals, and other printed matter.

Total apparent consumption of printing papers in 1958 was 0.6% less than in 1957; fine-paper consumption over the same period rose 4.3%. If the tonnages are combined, 1958 usage was 0.7% higher than apparent consumption the preceding year.

The Federal Reserve Board Index for the printing and publishing industries using these papers—that

POWER SAVINGS



R-C blowers for vacuum service are available in a wide range of sizes in both single-stage and compound units. Single-stage units range from 500 to 13,500 cfm capacity at vacuums up to 22" Hg. Compound units range from 1,500 to 15,000 cfm at vacuums up to 27" Hg.

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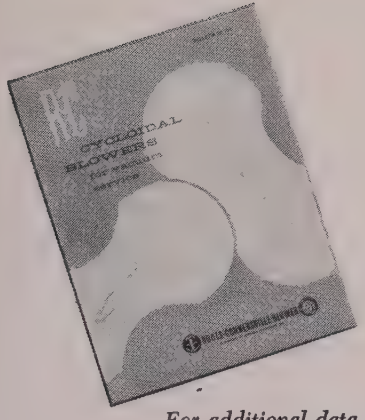


For additional data, please refer to pages 565-568 in **CHEMICAL ENGINEERING CATALOG,** *our section in* **MECHANICAL CATALOG** *or write for* **Bulletin VP-158.**

Because R-C cycloidal blowers for vacuum service operate at higher speeds with reduced horsepower, power savings of as much as 25% are often possible. Their simple design and rugged construction assure superior performance, low maintenance and long life. These advantages derive from the high volumetric efficiency of the design, low mechanical friction and installation flexibility. Minimum sealing water effectively overcomes slippage loss . . . as little as 4 gpm may be required.

R-C blowers for vacuum service are used throughout the world in a large number of industries. In chemical processing, R-C blowers have many applications in the handling of nitrogen, hydrogen, acetylene, moist air with SO^2, and other oil and gas mixtures. In paper-making, R-C blowers supply vacuum for suction rolls. In mining, R-C blowers provide vacuum for flotation, filtration and other ore processing requirements. And throughout general industry, they are used for carburetor testing, pneumatic conveying, food processing, cigarette tipping machines, aircraft component testing and many other applications.

Only Roots-Connersville vacuum equipment offers so many advantages — exclusive rotary positive design, ease of installation, efficiency of operation, and long years of trouble-free service. These features are the result of R-C's specialized experience of more than 100 years in the design and application of air and gas handling equipment.

ROOTS-CONNERSVILLE BLOWER
DIVISION OF DRESSER INDUSTRIES, INC.
859 Maple Avenue, Connersville, Indiana. In Canada—629 Adelaide St., W., Toronto

is, all of the industries other than newspapers—showed no change in production from 1957 to 1958. An unchanged level of operations suggests that there was little change in tonnage of paper used.

Of the individual industries whose operations are reflected in the FRB Index, periodicals are the largest users of paper. The amount they use depends upon their circulations and advertising. Circulations continued upward in 1958, but advertising declined. Of some 500 periodicals whose advertising content is regularly published, only farm publications showed a gain (1.6%) in pages over 1957. Consumer magazines, accounting for the major portion of paper that goes into periodicals, had an 8.3% loss in pages and business publications 11.5%. The combined loss for the three segments was 6.2%. Circulation gains may have offset the decline in paper usage indicated by the loss in advertising but probably were not sufficient to raise consumption above the 1957 level.

An indication of paper usage in books is provided by the Index of Book Manufacturing Activity, based on casing-in operations of 20 firms, and published by the magazine *Book Production*. Operations were substantially below 1957 levels for two-thirds of the year, but fourth-quarter increases in production reduced the net loss for 1958 to 5.3%. A considerable volume of book printing is done in plants not covered by the Index, but no data are available on their levels of operation. Preliminary and incomplete reports of publishers' sales show a small increase in the number of books sold in 1958, but this could have been accomplished from publishers' inventories and would not be inconsistent with a drop in book production.

The greeting-card industry probably increased its paper consumption in 1958; its 15.6% increase in production workers indicates a higher level of operation. Lower levels of employment in the other industries suggest a slight drop in their usage of paper. Little, if any, effect on paper consumption can be attributed to changes in direct-mail and outdoor advertising volume. Expenditures for direct-mail advertising were 8% higher in 1958 than in 1957, but the increase probably did not appreciably raise paper consumption. Similarly, the 4.3% drop in the outdoor advertising index was too small to effect a noticeable reduction in the amount of paper used in outdoor posters.

The projected demand for printing and fine papers in 1958 was 5900 tons. Apparent consumption totaled 5555 tons, 6% less than the projection, which was based on assumptions regarding levels of economic activity and employment that did not materialize. Undoubtedly the recession affected requirements for many printed products going to commercial and industrial users, as well as expenditures for advertising, both printed and broadcast. (The *Printers' Ink* estimate of total advertising dollar volume showed a loss of 1.1% from 1957, with only television, regional farm publications, and direct mail registering gains in 1958.)

Also tending to depress requirements in the printing and publishing industries is the trend toward lighter weight papers, particularly those used in periodicals. Three annual increases in second-class mail rates, the first of which became effective on January 1, 1959, provide sufficient incentive to publishers to continue the trend. Similarly, higher third-class rates are expected to affect tonnage requirements for catalogs and advertising matter, both through the use of lighter weight papers and more efficient mailings to reduce duplications.

The projected 1960 requirement of printing and fine papers, 6200 tons, is approximately 11% higher than 1958 apparent consumption, indicating a level of usage in 1959 of around 5.5% above 1958.

Insofar as consumption of paper in the printing and publishing industries is concerned, it is likely that the rising level of economic activity will be reflected in an increased demand for all kinds of printed matter used commercial and industrial establishments, and in larger expenditures for advertising, with benefit to printed advertising of all kinds. Industry-wide efforts to sell periodicals as an advertising medium and the introduction of novelties in the form of booklet inserts and special page folds and die cuts, which increase the sales appeal of the periodical to advertisers, should further stimulate periodical advertising. Population increases, rising school enrollments, the lengthened period of schooling, and scientific and technological developments that increase the need for printed media of communication widening the market for books and periodicals.

While all of these factors tend to increase the requirement for paper in the printing and publishing industries, they are offset to some degree by the movement toward lighter weights and by operating economies in the consuming industries designed to reduce transportation, storage, and production costs.

Postwar trends in total apparent consumption of printing and fine papers indicate that the assumed increase for 1959 is not unreasonable. At this time, however, it appears that the printing and publishing industries will increase their usage at a somewhat slower rate than has been assumed for all consuming industries.

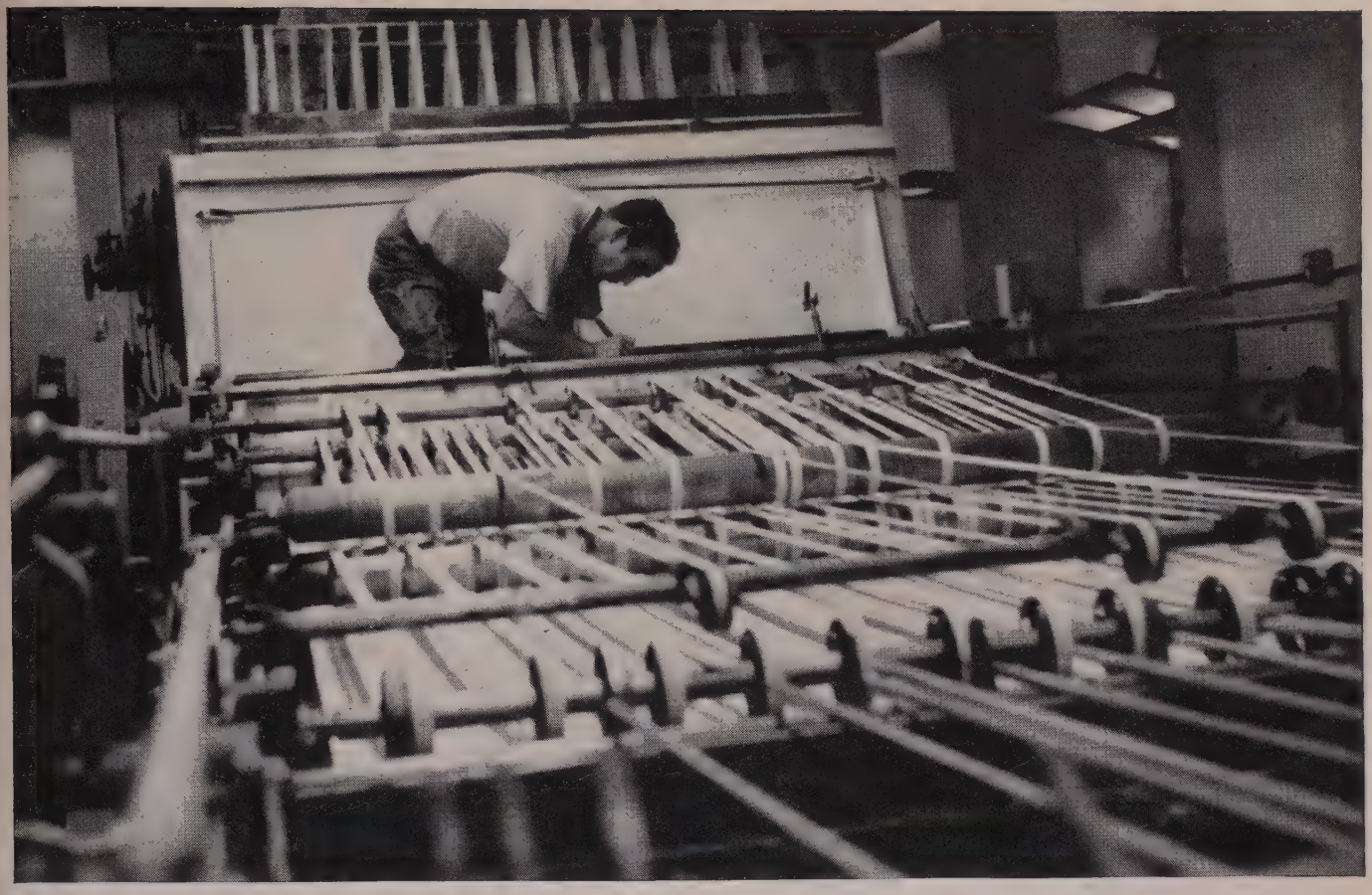
IV. UNITED STATES PAPER AND BOARD CAPACITY

Production capacity data for paper and board, as presented in this report for the years 1957 through 1961, are based on the results of a survey conducted in late 1958 and released in February 1959, by the American Paper and Pulp Association and the National Paperboard Association.

The associations use two methods of measuring capacity, historical and maximum or all-out.

The historical method assumes an end-of-year capacity on the basis of 310 days' production per year for paper and 313 days' production per year for paperboard, substantially the equivalent of production at the rate of six 24-hr. days per week for the 52 weeks of the year. This method is the one traditionally used by the industries and maintains continuity with earlier series.

The maximum or all-out basis, used for paper and paperboard year-end capacities, is the maximum that can be theoretically produced in any year, with allowance only for annual repair down time and restrictions of union contracts such as for holidays. This basis is useful because in certain periods machines may operate as much as 7 days a week for many weeks during the year and in emergency periods this rate has been



Burd & Fletcher Co., Kansas City, Mo., report

"Cities Service Pacemaker 42 Wax gives best results, bar none"...

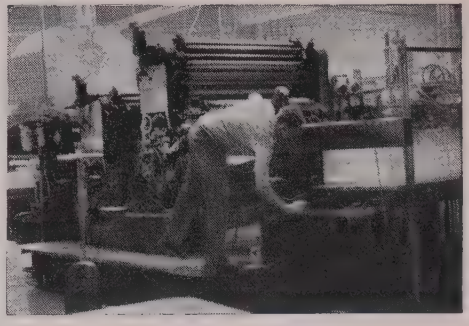
Burd & Fletcher Company originally started in 1886 as a printing company and then progressed to boxmaking. By 1936 they were producing as many as 2,000,000 boxes a day. Now, Burd & Fletcher is one of the largest paper box manufacturers in the Midwest area, using several hundred tons of paperboard each month.

Burd & Fletcher know that the box they produce can be no better than the wax they use and the coating the box receives. **And after extensive testing, they selected Cities Service Pacemaker 42 for coating their special food boards.**

The production department likes Pacemaker 42 for its cleanliness . . . keeps machines running cleaner. Burd & Fletcher also found that Pacemaker 42 produces a smooth gloss . . . better than others tested. Further testing showed Pacemaker 42 gives a full coating, prevents leakers and does not block. **Mr. R. T. Guernsey, Vice President of Burd & Fletcher, especially recommended Cities Service Technical Service Department for their fast, efficient help.**

Contact your nearby Cities Service office for a Wax Representative to give specific recommendations for your operation . . . or for further information, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

Special Cities Service CarTons facilitate easy handling and efficient storage of wax. Local warehousing cuts delivery time and reduces necessary inventories.



Seventy Years Ago Burd & Fletcher used a far smaller press compared to this high-speed giant. When the firm started in 1886, their prime business was printing catalogues.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

TC-Hydro is a dry, white, free flowing, crystalline powder of uniform size and structure. It is dust free, assuring highest stability and uniformity.

As Miners Of Sulfur Bearing Ores – We have utilized our basic position in Sulfur Chemistry to produce another product of highest purity and quality for use in the Southern Pulp and Paper Industry.

When You Need It – Our production is located in the heart of the Southern Pulp and Paper Industry which permits us to render overnight delivery service to most Southern points—also small lot shipments are available from centrally located warehouses.

Phone, Wire or Write for literature and test samples if desired.

TC TENNESSEE CORPORATION

TENNESSEE CORPORATION

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sustained in some operations for a very considerable period of time. To attain these all-out capacity figures, there must be the maximum demand coupled with a free flow of the necessary raw materials, labor, and power.

The maximum method of measuring capacity was first devised for use in the basic Pulp, Paper, and Board Supply-Demand Report of 1957, and it is particularly useful in determining potential all-out production which may be required in times of emergency demand, such as occurred during the Korean war and in the peak economic development cycles of 1955 and 1956.

Year-end capacity data for newsprint represent the prevailing operating schedule in terms of number of days per year of the individual mills. Data on changes in the capacity of hardboard, which is included in building board, for the years 1958–61 were not made available for use in this survey. Consequently, the building board totals developed in 1956, and reproduced in House Report No. 573, Pulp, Paper, and Board Supply-Demand, have been used here, supplemented by data for insulation board supplied by the Department of Commerce.

Capacity data for both methods of measure, as collected by the associations, were reported on a year-end basis only. For the purpose of this report, it was necessary to establish an annual capacity in order to obtain a better relationship with annual demand. Annual capacity for all major grades of paper and board, with the exception of newsprint for the years 1956 through 1959, was determined by adding capacity for the beginning and end of each year and dividing by 2. Annual capacity for newsprint for 1956 through 1959 was calculated by the Newsprint Service Bureau from information reported by producers.

Production of total paper and board in 1958 was 30.8 million tons, 86% of capacity on the annual historic basis, and 80% on the annual maximum basis. Ratios of production to annual historic capacity for the major grade groups under total paper and board for 1958 ranged from 70.3 to 100.7, in accordance with the dictates of variable demand. The ratio of production to capacity of 100.7 was for sanitary and tissue paper and may be misleading because it was the result of the flexibility of paper and board manufacturing facilities rather than a deficit in capacity.

An illustration of this flexibility appears in several of the grade breakdowns which show production or required production as over 100% of capacity. However, what appears to be a shortage of capacity is actually the adaptability of paper and board manufacturing units to the production of more than one grade. For example, it is possible to produce either sanitary tissue or building paper on the same machine.

No one machine is confined to one grade, and switching is sometimes necessary to comply with demand. However, the maximum daily tonnage that can be produced on a single unit may not be the same for both the interchangeable grades. A machine that is adaptable to the production of both coarse paper and container board may have a potential maximum output of 200 tons daily for kraft paper and 600 tons daily for linerboard. As a result, production for a particular grade for a given year may exceed stated annual capacity whereas the ratio of production to capacity for the

What do you see in this quiet picture?

❶ Is it a "still" ( ) or an action photo? ( )

❷ Are the men working?
Yes ( ) No ( )

❸ Which is the parent roll?
Left ( ) or Right ( )

❹ See any movement? Look closely!
Yes ( ) No ( )

❺ Machine-day is 8 hrs ( )
12 hrs ( ) 24 hrs ( )

❶ The papermaking process doesn't stop for candid photographs. If you checked "action" you're right. The winder has just started a new run. In a few seconds the winding speed will be well over a mile a minute.

❷ That three-man crew is working! Their watchful attitude tells you that the winding operation is completely automatic. Every 8 minutes the crew unloads (automatically) and starts a new 7,000 lb. roll. They're watching the slitter units, web tension, and winder speed, and are ready when necessary to make instant automatic adjustments at the control panels.

TEST YOUR POWERS OF OBSERVATION

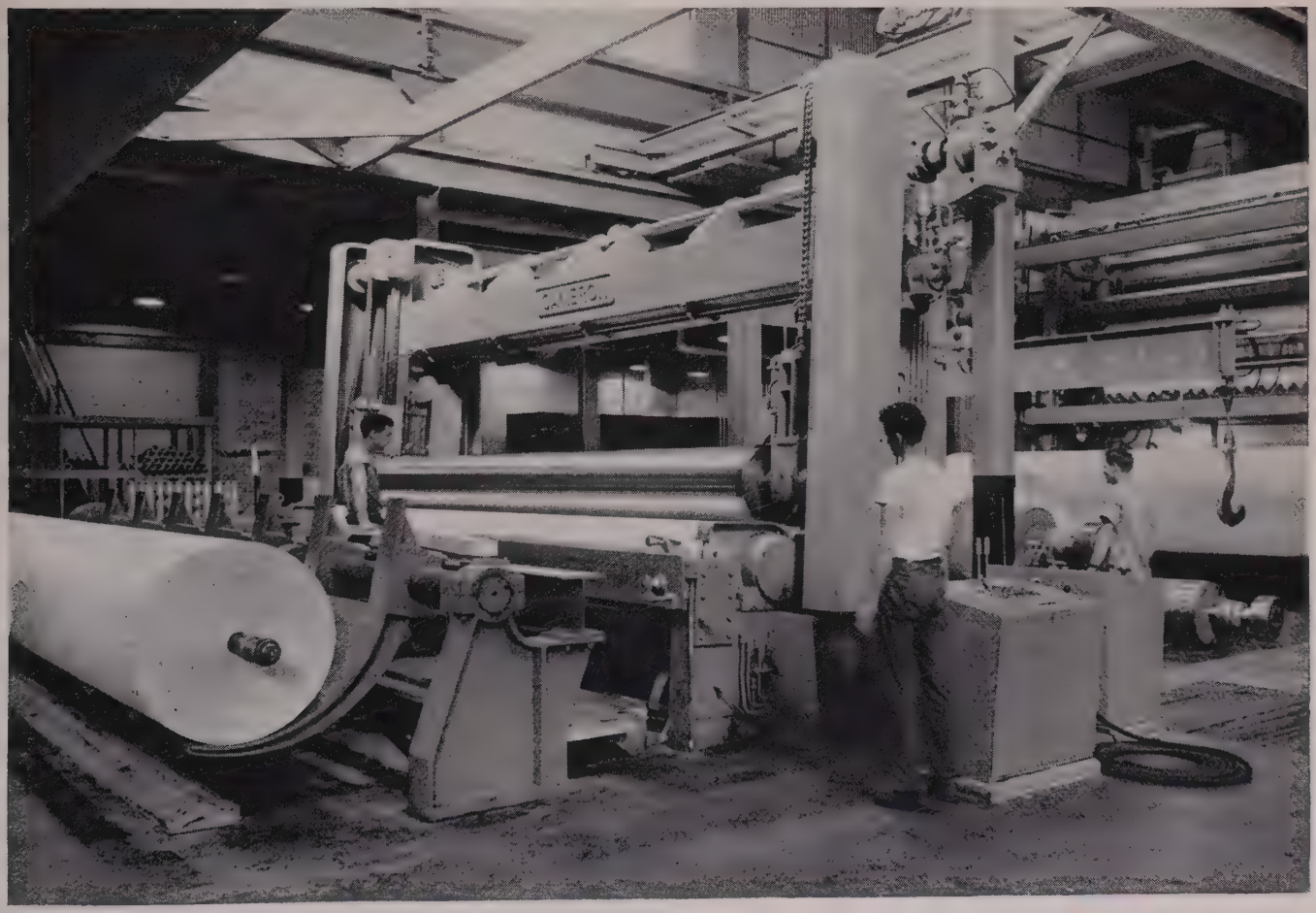
The unretouched candid photograph reproduced below was made at Southland Paper Mills, Lufkin, Texas by a UPI photographer. What you see in it depends on how well you know your winders. Read the questions, then check your answers in the numbered paragraphs.

❸ The parent roll is at the right. You can recognize it by the rough telescoping of its side. The finished roll at the left was unloaded seconds ago. You can tell by the exceptionally smooth, flat side *(unretouched)* that it is a perfect roll, uniformly wound from core to circumference. Cameron Imperial Winders are built to produce perfect rolls every time, automatically.

❹ You probably saw the slight blur as the control operator moved his left hand. The winder is sharp in every detail because there is no vibration. Performance is just as quiet as it looks, even at top speeds with a full payload. The dynamic thrust of almost three tons of paper winding at well over a mile a minute is tamed by the perfect balance, fine engineering, skilled craftsmanship and rugged construction of the winder.

❺ Twenty-four hours is "right" in every busy paper mill. The only change is in the crews. Cameron Imperial Winders are built to stay on the job 24 hours a day at speeds well ahead of the peak requirements of any mill.

THE NAME at the top of the machine tells you it's the fastest winder in the world—the Cameron Imperial—now available with speeds up to 8,000 fpm on newsprint, rewind diameters up to 72", pneumatic score-cut or shear-cut slitting, and automatic controls. If you are interested in fast, low-cost production of better newsprint, paper or paperboard rolls, why not consult with the Cameron Team of Specialists?



AA-365

Cameron Machine Company, Franklin Road, Dover, N. J.

Canada: Cameron Machine Co. of Canada, Ltd., 15 Hatt St., Dundas, Ontario

France: Batignolles-Chatillon, 5 Rue De Monttessuy, Paris (7e) France

CAMERON
a team of specialists

53 years devoted exclusively to the design and manufacture of slitting, roll winding, unwind and web control equipment.

alternate grade may be low. Thus, the best relation of production to capacity is available from figures for total paper or board.

Owing in part to slackening of demand in 1957 and 1958, about 1 million tons of capacity intended for 1959 were canceled or postponed. However, annual historic capacity for total paper and board of 37.3 million tons, as now proposed for 1959, is 21% above actual production for 1958. On the maximum basis, annual capacity of 40 million tons as proposed for the current year is 30% above last year's production.

A margin of capacity over actual or anticipated production is both desirable and necessary to meet seasonable peaks in demand. In recent years, monthly production has varied from 80 to 120% of average monthly output. In 1958, production ranged from a low of 2.4 million tons in February to a high of 2.9 million tons in October. Such variation in monthly demand necessitates a substantial amount of surplus capacity to meet production in peak months.

Annual historic capacity as now planned for 1959 (21% over 1958 production) is sufficient to meet increased annual demand at a rate equal to the highest required in the last 10 years. The largest year-to-year increase in production of total paper and board in the last decade occurred in 1950 when output rose 20% over 1949.

Capacity for total paper and board as planned for 1960, on the annual historic basis, is 38.3 million tons, and on the annual maximum basis 41.1 million tons. Production required to meet estimated total paper and board demand in 1960, as projected in the basic Supply-Demand Report, is 36.5 million tons. Provided both the demand and capacity expected for 1960 are realized, the operating ratio of production to capacity for the year will be 95 on the historic basis and 89 on the maximum basis.

Total paper and board capacity as now planned on the annual maximum basis for 1960 of 41.1 million tons would be sufficient to meet an increase in production of 15% annually for 1959 and 1960. The highest such increase for 2 consecutive years in the last decade was 13% for 1950–51.

For 1961, annual historic capacity is expected to be 39 million tons, and annual maximum capacity 41.9 million tons. Estimates for required production in 1961 were not made.

Plans for expansion of capacity are subject to changes, depending principally on general business activity. Expansion programs planned for 1960 and beyond are naturally more likely to be altered than those for the current year. Therefore, the associations that supplied the capacity information used in this report did not consider it practical to differentiate between programs that were committed and those that were only proposed, as presented in the basic report of 1957. No surveys of domestic capacity were made for any year beyond 1961.

V. UNITED STATES WOODPULP PRODUCTION AND CONSUMPTION

Woodpulp production by United States mills (including Alaska) during 1958 amounted to 21.7 million tons, a drop of only 66,000 tons below 1957 ,which was principally the result of a decline in exports. Imports remined at the same level as the previous year. Woodpulp consumption by all mills during 1958 was reported at 23.3 million, the same as in 1957. Woodpulp consumption by paper and board mills amounted to 22.5 million tons, an increase of 46,000 tons over 1957, while consumption in nonpaper mills dropped 38,000 tons to 842,000 tons in the same period.

Three grade groups of woodpulp registered production increases in 1958 over 1957: white pulp production at 7.4 million tons was up 131,000 tons (1.8%); unbleached sulphate at 7.7 million, up 21,000 tons (0.3%); and other pulp at 1.2 million tons, up 65,000 tons (5.5%). All other grades declined: dissolving, down 78,000 tons (7.7%) to 0.9 million tons; groundwood, 170,000 tons (5.5%) to 2.9 million tons; and semichemical, 35,000 tons (2.2%) to 1.5 million tons. The largest percentage decline occurred in dissolving pulp, which is consumed principally in the manufacture of products other than paper and board (chiefly rayon, acetate, and cellophane).

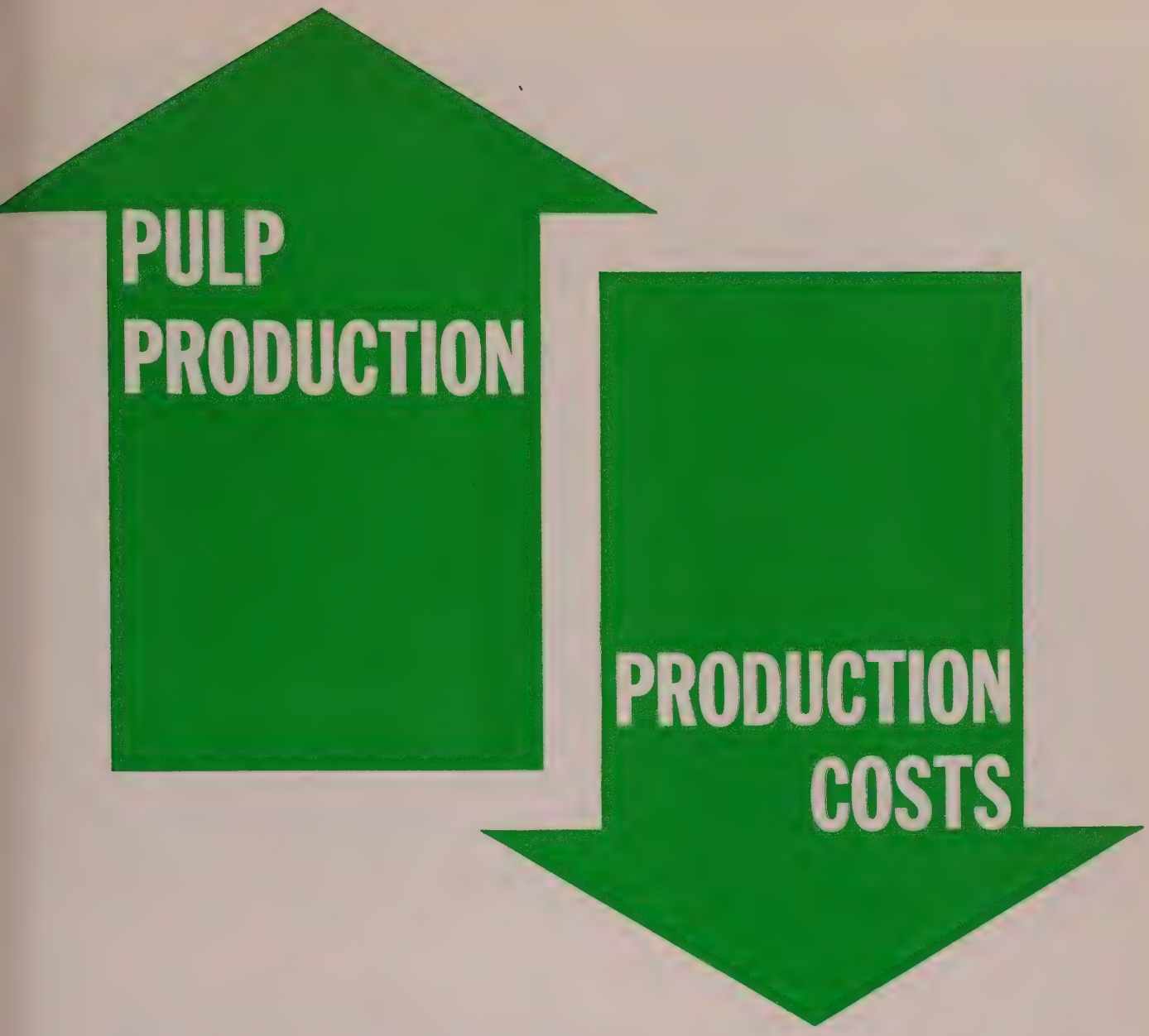
Imports of woodpulp at 2.1 million tons in 1958 were unchanged from 1957 although divergent trends were noted. White pulps increased 59,000 tons (4.1%) to 1.5 million tons above 1957 while all other grades showed decreases, principally groundwood which declined 29,000 tons (12.7%) below 1957.

Exports of woodpulp during 1958 amounted to 515,000 tons, 107,000 tons (7.2%) below 1957. (Revised 1957 export data disclose that unbleached sulphate pulp originally reported at 186,000 tons and white pulp at 181,000 should have been 69,000 tons and 298,000 tons respectively.) In 1958 dissolving pulp exports totaled 223,000 tons, 27,000 tons (10.8%) below 1957. White pulp exports, at 218,000 tons, drooped 80,000 tons (27.1%) from the revised figure of 298,000 tons for 1957.

Consumption of woodpulp in paper and board mills as reported for 1958 shows that white pulp at 8.7 million tons increased 250,000 tons (2.9%) over 1957; unbleached sulphate at 7.8 million tons declined 89,000 tons (1.1%); groundwood at 3.1 million tons dropped 162,000 tons (5.0%); semichemical dipped slightly (24,000 tons or 1.5%) to 1.6 million tons. Other pulp, at 1.3 million tons, rose 81,000 tons (6.9%) above 1957.

Actual 1958 production of woodpulp, totaling 21.7 million tons, was materially below the estimated required United States production of 23.9 million tons, as projected in the basic supply-demand report. The pattern of domestic woodpulp production and consumption closely parallels the trend in paper and board production and consumption outlined in Section II of this report. Furthermore, consumption of woodpulp in nonpaper products declined substantially in 1958. In fact, domestic woodpulp production in both 1957 and 1958 was below the record output of 1956.

The projected required United States production of woodpulp for 1960 of 26.2 million tons would represent an increase of 4.5 million tons or 20.7% over actual production in 1958. The possibility of actual 1960 pulp production reaching the projected figure hinges principally upon a much larger than normal average annual growth in paper and board and nonpaper products production as reviewed in Section II. An



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More mills than ever are looking at Ammonium Bisulfite Pulping as an economical way to increase pulp output. Mills that have already converted to ABP are now realizing the substantial cost savings this process gives them.

With little increase in capital investment, ABP shortens cooking time, thus reducing the cost of steam per ton of pulp while it increases digester output 20% or more. Yields from the wood itself go up too, because there are fewer rejects during screening. A wider choice of pulpwoods—soft or hard — is a bonus advantage.

The ammonia process eliminates entirely the maintenance problems caused by "liming up." Easier pollution control further reduces costs.

Another fact you should know: Allied Chemical pioneered ABP, and Allied's technical specialists can help you with detailed information as you weigh its merits for your mill. Call them in for an exploratory talk.

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NITROGEN DIVISION
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upward trend in woodpulp exports would also be a factor.

For 1965, projected United States required production of woodpulp, amounting to 32.4 million tons, represents an increase of 49% over 1958 or an annual average increase of 5.9%.

VI. UNITED STATES WOODPULP CAPACITY

The latest survey on United States woodpulp capacity for the period 1958–60, conducted by the U. S. Pulp Producers Association, shows no appreciable change from their survey of the previous year.

For 1958, such capacity was reported at 27,700,000 tons, compared to domestic production of 21,734,000 tons. Thus 1958 production amounted to about 79% of stated capacity compared to a maximum operating rate of about 94% of stated capacity in the best previous year.

Total stated woodpulp capacity by 1960 is expected to be increased by 1.2 million tons above 1958, to a total of 28,900,000 tons. Projected required domestic woodpulp production of 26,200,000 tons in 1960 would yield an operating rate of about 91% of capacity.

The following is the definition of capacity employed by the U. S. Pulp Producers Association:

"Stated" Annual Capacities are the maximum tonnages of grades and qualities considered normal, that would be produced to meet full demand, assuming no unscheduled shutdown of facilities. "Stated" annual capacities, accordingly, make no allowance for average time lost due to strikes, power failures, water shortages, or other emergencies beyond the control of management. While "stated" annual capacities are often achieved for relatively short periods, they have never been achieved for an entire calendar year.

"Total" Annual Capacity, for each mill, is its reported daily capacity multiplied by the number of days of scheduled operation. New capacity installed in a given year is included only for the number of days that the new facility could operate within that calendar year.

Grade Capacities. Total annual capacities have been divided into grade capacities in accordance with the reported planned use of total facilities.

"Practical" Annual Capacity can be estimated, for purposes of supply-demand studies, by examining rates for years of full operation. For such years, the highest operating rates achievable, on a calendar year basis, have been as follows: Chemical woodpulp, 97–98% of stated capacity; groundwood, 84% of stated capacity; total woodpulp, 94% of stated capacity.

VII. FIBROUS RAW MATERIALS CONSUMPTION

The consumption of pulpwood and other fibrous materials, except wastepaper, declined in 1958 from the 1957 levels. Wastepaper consumption increased 2% during this period in which paper and board production rose only slightly (0.4%).

Total pulpwood consumption in 1958 was 35,229,000 cords, or 517,000 cords (1.4%) below 1957. Wastepaper consumption reached 8,670,000 tons, 177,000 tons more than in 1957. Consumption of other fibrous materials such as rags, straw, cotton linters, and bagasse amounted to 1,042,000 tons, a decrease of 64,000 tons (5.8%) from the 1957 level of 1,106,000 tons.

Since 1947, pulpwood consumption has risen from 19.3 million cords to 35.2 million cords. During this period, softwood pulpwood has experienced a declining ratio, from 86.8% to 81.8% of total consumption in favor of hardwood pulpwood which rose from 13.2% to 18.2%.

VIII. WORLD NEWSPRINT SUPPLY-DEMAND 1957–60

This is a reappraisal of the world newsprint supply-demand section of the report, Pulp, Paper, and Board Supply-Demand, supplemental report of May, 1958.

Questionnaires were sent in mid-1958 to the Foreign Service posts of the United States in the 63 foreign countries which, together with the United States and Canada, account for 99% of the free world's newsprint production and consumption. Data for the Communist bloc of countries have been estimated to round out the world picture.

The Foreign Service was requested to submit data on newsprint production, capacity, imports, exports, and consumption for the year 1957 and to supply estimates for 1958–60. An analysis of these reports discloses a resumption of newsprint expansion projects, and for each year, 1958–60, moderate increases are shown in the total world's newsprint production potential. The estimates of production potential have been based, as before, on reasonably definite newsprint expansion projects and include only those planned expansions or new mills expected to be in operation during this period.

Total World

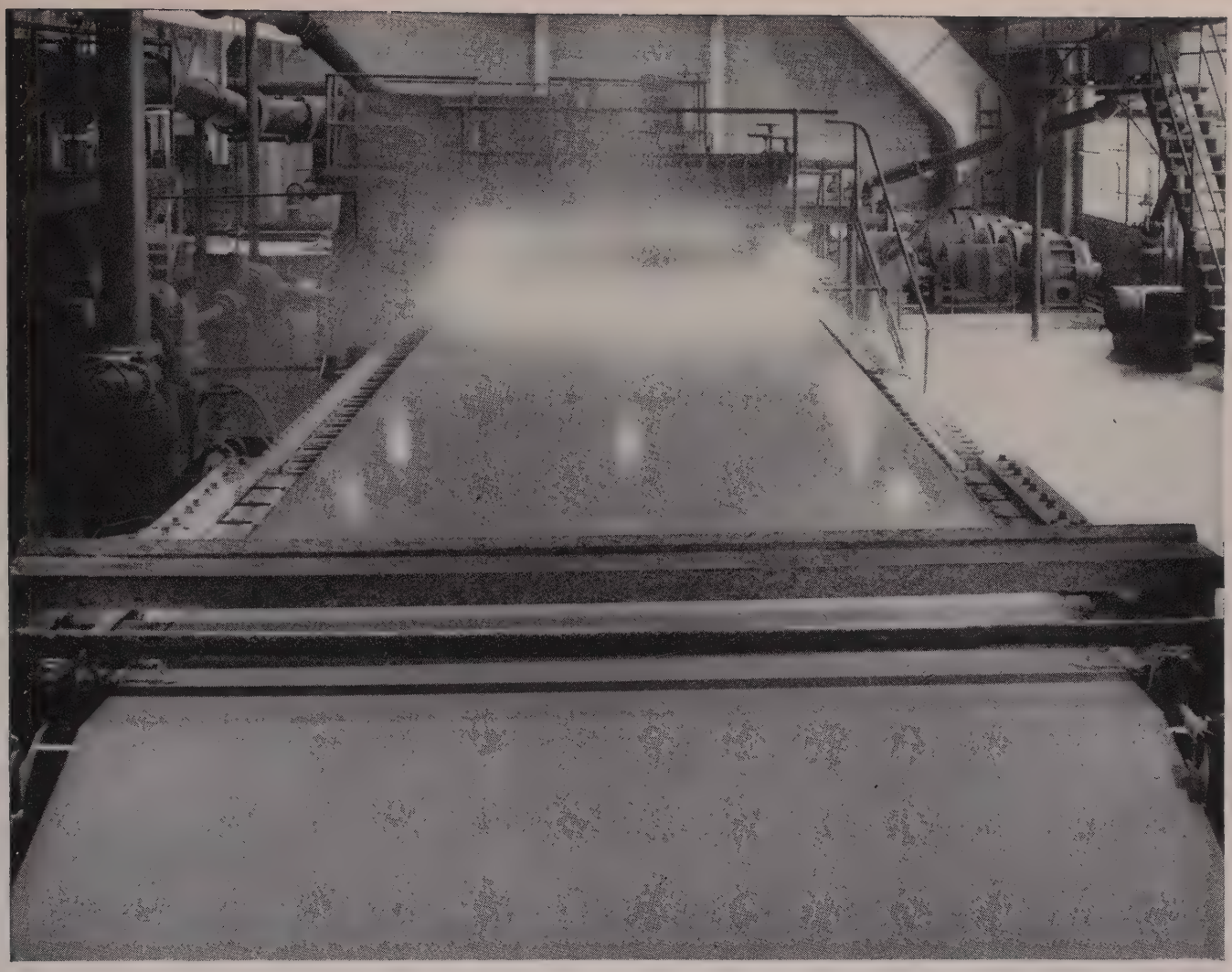
Apparent world newsprint consumption in 1957 amounted to 13,880,000 tons, up 375,000 tons from 1956. World production at 13,965,000 tons was 347,000 tons over 1956. The 1957 production potential reached 14.8 million tons, 913,000 tons more than apparent consumption.

The United States accounted for slightly less than one-half (6,771,000 tons) of the world's consumption of newsprint; the United Kingdom was the next largest consumer at 1,107,000 tons. The Western European countries consumed an estimated 2,030,000 tons and the Communist countries an estimated 1,136,000 tons in 1957. The largest increase in consumption of newsprint tonnage from 1956 to 1957 was in the Western European countries, up 200,000 tons; Asian countries rose 83,000 tons. Decreases in consumption during the 1956–57 period were noted for the United States and Canada of 36,000 and 20,000 tons, respectively.

The 347,000-ton increase in 1957 newsprint production over 1956 was contributed largely by the United States (177,000), Northern Europe (51,000), Western Europe (58,000), Asia (53,000), and an estimated 49,000-ton increase in the Communist countries. Canadian production was down 72,000 tons.

World newsprint production potential in 1957 at 14.8 million tons was 913,000 tons above apparent consumption, affording a more confortable degree of reserve capacity for the world. Over one-half of the 1957 world surplus of newsprint production potential over actual output was in Canada and the United States. If expansions continue, by 1960 the world should have slightly more than 2 million tons of surplus capacity over estimated demand, sufficient to meet any unforeseeable rise in demand as occurred in 1955 and 1956.

As reviewed in the basic supply-demand report of 1957, there has always been production flexibility for the average paper and paperboard mill, mostly limited



A Complete Starch Line... *tailor-made to your needs*

Today's complex papermaking operations require a wide range of starches—starches specifically designed to do a particular job. You'll find that the complete starch line offered by Corn Products Company includes types for every phase of modern papermaking. These starches are available in so many varieties that *they can literally be tailor-made to suit individual requirements* and production problems of individual plants!

For example, in beater sizing, preferred starches for improved surface qualities plus excellent bursting and tensile strength, include the many varieties of Globe and pre-cooked Amijel. For calendar sizing, you'll find a complete line of Claro and Eagle starches, as well as Globe starches for enzyme conversion. In this operation, Globe and Excello dextrines and thin-boiling Foxhead starches are also used. For general coating, with good viscosity at high solids content, use Claro and new improved Ten-O-Film starches.

And the research staff of Corn Products Company, largest in the industry, is constantly at work developing new products to meet the changing needs of modern papermaking.

Our technical representatives are completely versed in the problems that arise with wet end additives. Their impressive field experience and continuing research into starch, evidenced by frequent publications in trade and technical journals*, is always at your service. Take full advantage of the facilities and experience of the world's largest corn processors—call our nearest sales office or write direct.

Fine products for the Paper Industry: GLOBE® • EAGLE® • FOXHEAD® • CLARO® • AMIJEL® CORAGUM® • TEN-O-FILM® starches • GLOBE® • EXCELLO® • LAM-O-DEX® dextrines and gums.

CORN PRODUCTS SALES COMPANY 17 BATTERY PLACE, NEW YORK 4, N.Y.

to switching between associated grades within a particular grade group. For example, a newsprint mill may utilize its capacity to produce groundwood printing and converting papers, depending on market conditions. This observation should be considered in evaluating the newsprint production potential figures contained in this report.

United States

Newsprint consumption in the United States declined 36,000 tons in 1957 to 6,771,000 tons, from the record high of 6,807,000 tons in 1956. Consumption during 1958 is calculated to be 6,501,000 tons, a 4% drop of 270,000 tons from 1957, which can be attributed in part to the decline in newspaper advertising and labor strikes against newspaper publishers.

The estimated demand for newsprint consumption in the United States has been revised for 1959 from 7,180,000 tons to 7,000,000 tons. The considerations which prompted this revision are fully explained in Section III.

Newsprint production in 1957 reached an all time high of 1,797,000 tons and then dropped 4% to 1,723,000 tons in 1958. The production potential, at 2,100,000 tons in 1958, is expected to reach 2,488,000 tons in 1960. Most of the capacity increases are expected to originate in the South.

Imports of newsprint amounted to 5,221,000 tons in 1957 and 4,883,000 tons in 1958, for successive drops of 6% in the 2 years after the record 1956 level of 5,569,000 tons. Virtually all of the imports in 1957 and 1958 were from Canada and Finland; 4,774,000 tons, or 98%, originated in Canada during 1958. United States exports in 1957 and 1958 were 174,000 and 127,000 tons, respectively. Latin America, Mexico, The Philippines, and Asia combined represented 78% of the 1957 total and 84% of the 1958 total newsprint exports.

Canada

Canadian newsprint production in 1957 amounted to 6,397,000 tons, a drop of 72,000 tons from the record 1956 production. Production in 1958 at 6,096,000 tons was 301,000 tons below 1957. Canadian shipments to United States customers at 228,000 tons less than 1957 accounted for the largest share of the 321,000 tons total drop in shipments from 1957. Declines of 71,000 tons in shipments to other overseas markets and 22,000 tons in Canadian consumption accounted for the balance. Canadian mill stocks at year's-end were 52,000 tons above 1957 and 85,000 tons over 1956.

The Canadian newsprint production capacities reported in last year's report for 1958 and 1959 have been revised slightly on the basis of recent information from the Newsprint Association of Canada, the former from 7,275,000 tons to 7,239,000 tons and the latter from 7,550,000 tons to 7,521,000 tons. The 1960 total of 7,600,000 tons is unchanged.

The Canadian newsprint industry operated at an average of 94.7% of capacity in 1957, 84.2% in 1958 and 78.4% in the first quarter of 1959, according to the Newsprint Association of Canada. The actual and planned increases in Canadian newsprint capacity of about 20% in 1956–59 will enable Canadian producers to satisfy any sudden increases in demand for the next few years.

United Kingdom

The apparent consumption of newsprint in the United Kingdom during 1957 was 1,107,000 tons, no marked change from the 1956 level of 1,105,000 tons. Newsprint consumption is expected to increase gradually to 1,190,000 tons in 1960.

Newsprint production in 1957 amounted to 732,000 tons. The production potential of the United Kingdom should reach 875,000 tons by 1960 if stated expansion and improvement plans materialize. Imports are expected to decrease gradually as production increases, stocks are lowered, and exports decline.

Northern Europe

Newsprint production in Northern Europe (Finland, Sweden, and Norway) reached 1,362,000 tons in 1957, 51,000 tons over 1956. By 1960, the production potential is expected to reach 1,800,000 tons. Exports represent about 80% of production and the continuing oversupply of newsprint in the world may cause Northern Europe to curtail production to below capacity levels.

Finland's newsprint mills are expected to increase their capacity to about 880,000 tons in 1960, or 19% over 1957 capacity; and Sweden's to 670,000 tons, or 40% over 1957 capacity. New machinery installed in Norway will boost newsprint capacity in 1960 by 21% over 1957 capacity to 250,000 tons.

Western Europe

The apparent consumption of newsprint in Western Europe in 1957 was 2,030,000 tons, an increase of 200,000 tons over 1956 consumption. By 1960, the demand for newsprint in Western Europe is expected to reach 2,247,000 tons.

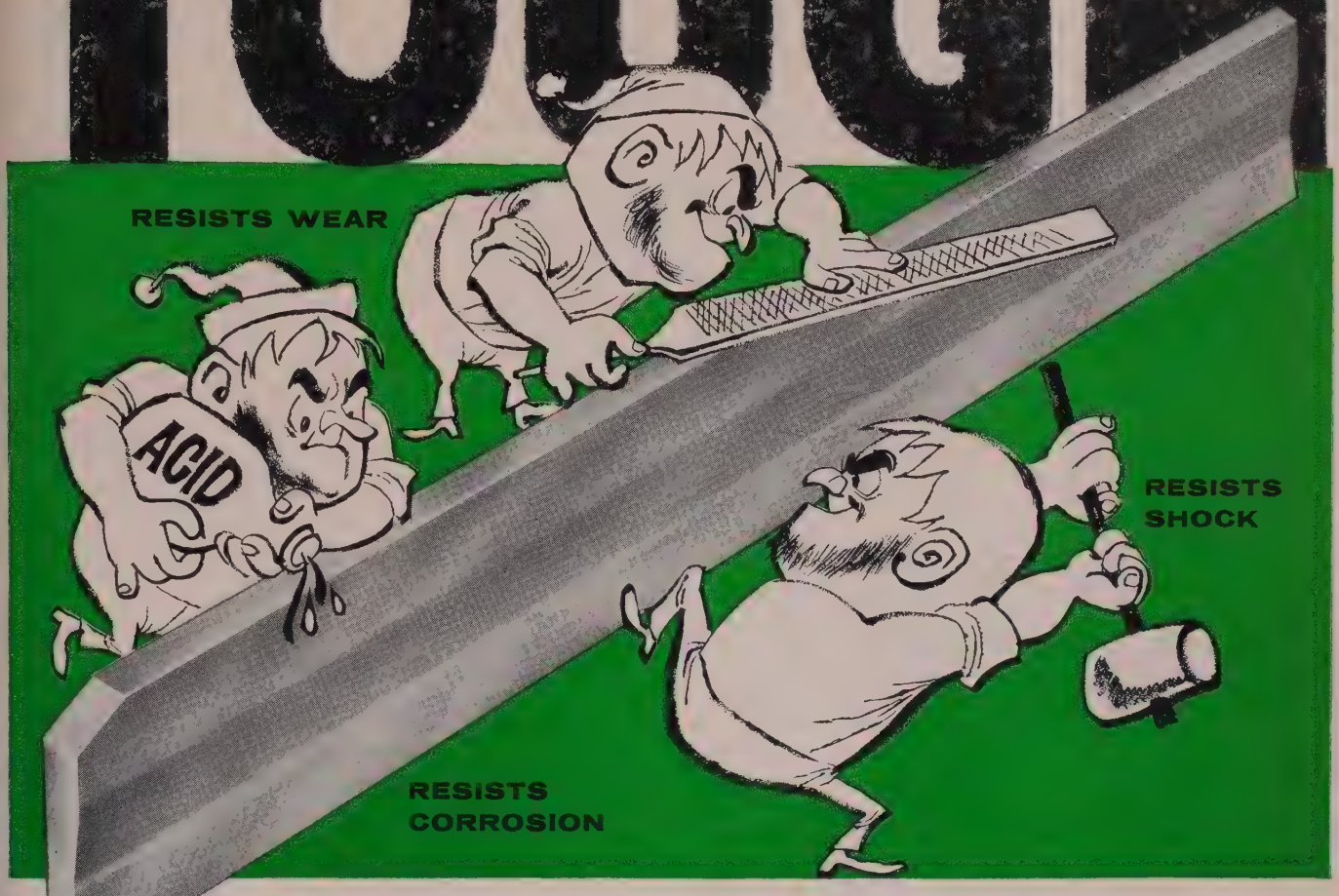
The production of newsprint in Western Europe in 1957 amounted to 1,570,000 tons, an increase of 58,000 tons over 1956 production. Increases in the major producing countries, Italy, France, and the Netherlands, more than offset the decreases reported in Austria and Western Germany, which had curtailed production for export due to plentiful world supplies. The production potential is estimated to reach 1,895,000 tons by 1960, for an increase of 259,000 tons over the 1957 production potential, largely due to the proposed newsprint capacity expansions in France from 496,000 to 696,000 tons during this period.

Imports of newsprint in 1957 by Western European countries amounted to 653,000 tons, 105,000 tons more than in 1956. Exports in 1957 totaled 193,000 tons, a decline of 37,000 tons from the 1956 level. By 1960, imports are expected to decline to 532,000 tons due in large measure to France's becoming self-sufficient. Exports are expected to show no appreciable change during this period, declining by 15,000 tons from the 1957 level.

Latin America

Newsprint apparent consumption in Latin America (South and Central America and the West Indies) in 1957 was 671,000 tons, an increase of 71,000 tons over 1956. Demand is estimated to continue upward by 66,000 tons in 1958 and then by about 42,000 tons a year until 1960, to reach 821,000 tons. An important factor in the recent rise of newsprint consumption in

TOUGH



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... custom heat-treated to meet the toughest Jordan applications

Now in one Jordan bar steel — Jones Super Stainless — you can get the exact combination of physical properties you need for your particular refining operations. Inherently corrosion resistant, this tough chrome-nickel alloy is *precipitation* hardened by Jones' expertly controlled heat treating. This custom process relieves stresses within the metal and brings it to the ideal degree of hardness and tensile strength for your requirements.

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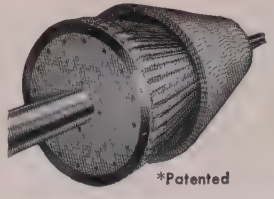

*Patented

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- **Maintains sharper cutting edges.**
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Latin America has been the lifting in 1955 of allocation controls imposed by the Peron regime in Argentina, where newsprint consumption has doubled since 1955.

Latin American newsprint production in 1957 amounted to 83,000 tons, or 12% of consumption, the balance coming from imports. By 1960, the production potential is expected to reach 222,000 tons or 27% of demand, attributable to the Chilean mill which came into production in 1956, the Mexican mill due to have begun operations in 1958, and the pending expansions and improvements at the Brazilian mill. Chile, an exporter of newsprint beginning in 1958, by 1960 should be able to export 45,000 tons to other Latin American countries thereby reducing porportionately the demand for North American and European newsprint. Imports of newsprint will continue to be the chief source of supply and are expected to reach 644,000 tons in 1960.

Plans for the erection of a newsprint mill in Colombia have not been carried out and the paper machinery is being disposed of; the starting date for the manufacture of newsprint from sugar cane bagasse in Cuba has not as yet been announced.

Africa

Newsprint consumption in Africa at 117,000 tons in 1957 showed practically no change from the 1956 level. Demand for newsprint, all by way of imports, is expected to reach 128,000 tons in 1960. The Union of South Africa, which accounts for about 60% of Africa's newsprint consumption, is planning to begin newsprint production in 1961.

Asia

The apparent consumption of newsprint in Asia, excluding China and North Korea, amounted to 911,000 tons in 1957, an increase of 83,000 tons over 1956. Japan, accounting for about two-thirds of the total in 1957, is expected to maintain its proportionate share in the Asian total for 1960, estimated at 1,108,000 tons.

Of the 1957 production total of 662,000 tons, Japan accounted for 613,000 tons. The remaining 7% was produced by India, Israel, South Korea, Taiwan (Formosa), and Turkey. The Asian newsprint production potential in 1960 is estimated at 1,008,000 tons for an increase of 218,000 tons over 1957 capacity. Japanese mills are expected to account for 185,000 tons of the increase. Other Asian newsprint-producing countries are expected to increase capacities greatly in the 1957–60 period; for example, India 20,000 to 30,000 tons and South Korea 9000 to 37,000 tons.

Taiwan (Formosa) has joined Japan and Israel in becoming self-sufficient during 1957 and is expected to have available for export about 13,000 tons of newsprint a year. Japan's production is expected to make 150,000 tons available for export in 1960. The remaining Asian countries will continue to rely on imports to satisfy demand, South Korea and India to a lesser degree.

Oceania-Hawaii

The apparent consumption of newsprint in Hawaii in 1957 was 14,000 tons, and is expected to rise slightly to 15,000 tons in 1959 and remain at that level in 1960. Since Hawaii was included in Oceania, because of its far-removed offshore location, in the basic Pulp, Paper, and Board Supply-Demand Report, it has been handled in the same manner in the tables of this report. In the future, data for Hawaii will be included with that of the other 49 States of the Union.

The apparent consumption of newsprint in Australia and New Zealand in 1957 was 359,000 tons. Estimated consumption for these two countries for 1960 is 410,000 tons, largely accounted for by the expected increase in Australian consumption from 289,000 tons in 1957 to 335,000 tons in 1960.

The increase in newsprint production in Australia and New Zealand to 162,000 tons in 1957 from 149,000 tons in 1956 was accounted for by the New Zealand mill which began operation in 1955. By 1960, the New Zealand mill is expected to edge the Australian mill in newsprint production at 105,000 tons. Inasmuch as Australian officials deferred an expansion project for newsprint production, it appears likely the largest share of New Zealand exports will be destined for Australian consumption.

In 1957, imports of newsprint into Australia and New Zealand amounted to 237,000 tons, slightly less than the 1956 level of 241,000 tons. By 1960, import requirements are estimated at 255,000 tons, but will be offset to a degree by the 45,000 tons expected to be exported from New Zealand to Australia.

China, U.S.S.R., and Satellites

Apparent consumption of newsprint in China, Russia, and their satellites is estimated at 1,136,000 tons and production at 1,200,000 tons in 1957, on the basis of very limited information. Exports of newsprint are estimated at 84,000 tons and imports at 20,000 tons during 1957. By 1960, newsprint demand and production potential are expected to increase about 8% above the 1957 levels to 1,225,000 tons and 1,300,000 tons, respectively. Little change is estimated in newsprint trade between these Communist countries and the rest of the world during the period 1958–60.

Fourth

Deinking Conference

of the

Technical Association

of the

Pulp and Paper Industry

Roger Smith Hotel, Holyoke, Mass.

Oct. 8–9, 1959.

NEW DU PONT SURVEY REVEALS THAT TREND TO COLOR IS INCREASING MARKET FOR COLORED PAPERS

After more than two years of planning and interviewing, Du Pont has recently completed a survey which explores the attitudes toward color in general—and colored paper in particular—among commercial printers, commercial artists and advertising agency art directors. The results are invaluable to paper mills because they reveal marketing opportunities for colored papers . . . and show where and how sales can be increased.

"Is More Color Being Used?"

The survey shows a definite trend toward increased usage of color in the printing industry. 84% of the printers feel this to be true, yet only 60% of them feel they are using more color in their own business. It appears that printers are lagging behind the trend, and that promotion is needed to make them fully aware of the trend and the opportunities it offers.

Actually, the printers who see color work increasing fully accept the positive advantages of it. They believe color gains greater attention, adds more life, and can be economically produced by offset. In terms of their own business, they feel that color has gained new business and produced greater profit. More than half, however, admit to problems involving equipment, personnel training and color matching. It can be concluded that printers favor color work, but would welcome help on its use and production.

(continued on other side)

HIGHLIGHTS OF COLORED PAPER SURVEY

Why Is More Color Stock Being Used?

Reasons Given by Printers	% OF MENTIONS
"Competition forces eye-catching color"	47%
"Color catches attention better"	27%
"Greater use in business forms"	17%
"Color stock more economical"	10%
"Better response in direct mail"	4%
"Customers prefer color if given choice"	2%

Reasons Given by Artists	
"Adds attractiveness, eye appeal, interest, attention"	66%
"Gives one more color"	55%
"Economy"	35%

BENEFITS OF COLOR TREND

Mentioned by Printers	
"Make more profit on color work"	48%
"Color has opened up new markets"	34%
"Color has increased the general demand for printing"	14%
"Get more personal satisfaction from color work"	11%
"Color work has given us a better reputation"	8%

news from Du Pont

NEW PAPER LABORATORY READY TO SERVE NEW ENGLAND

The Dyes and Chemicals Division of Du Pont announces it is now able to offer improved technical service to the paper industry in the New England area. A new laboratory, fully equipped and completely staffed, is now in operation at Rumford, R. I.

From this nearby location, New England mills can receive expert service on color matching, development of dyeing formulations, application problems, and evaluation of paper properties. The operation will be backed up by the extensive facilities of the Du Pont Technical Laboratory in Deepwater, N. J.

DU PONT COLOR COUNCIL STUDIES COLORED PAPER

In 1958 the Dyes and Chemicals Division had to admit that they knew little about the true possibilities of color stock in graphic design. The result: birth of a completely new group known as the Du Pont Color Council. Composed of men experienced in color, art and printing, this Council is now busily engaged in tracking down the real facts about colored paper, its uses, its advantages and disadvantages.

For example, some time ago you would have found Du Pont's head designer and printing supervisor both overlooking a series of experiments in a Philadelphia printing plant. Four-color plates were first run off on dark blue paper, then green, jet black and newsprint. Some printers might have thrown up their hands in horror. But the Color Council believes in trying anything that may contribute to a better understanding of color stock.

Other projects of the Council include the development of criteria showing how colored inks reproduce on various colored papers. Still another is a periodical publication suggesting creative uses of color stock. Members of the Council also help to present their findings at marketing seminars, trade shows and so on.

"How Much Colored Paper Do You Use?"

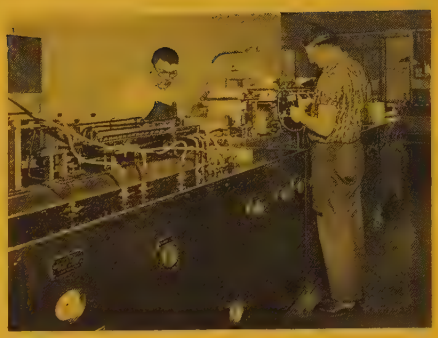
The trend to more color in general has also led to a widespread use of colored paper. In fact, 98% of the printers interviewed say they use colored paper during the course of a year.

On the average, though, their use amounts to only 24% of the total stock. It is evident that printers have wide experience in using colored paper but that the degree of usage is far from the ultimate potential.

The use of colored paper is also widespread among art directors and artists. 90% of them use it in designing collateral pieces, but the majority say that their use is limited to less than one-third of the pieces they work on. This is true in spite of the fact that 83% of them see real benefits in colored paper—specifically: added attractiveness and an extra color at low cost.

Printers, too, seem to be aware of colored paper's growing importance. Most of them, for example, think their industry is using more today. Like the artists, they feel that colored paper gains greater attention and offers a more colorful effect at small additional cost. In addition, they feel that colored stock has become a "must" in business forms and in a growing amount of direct mail. It is evident, then, that the climate is right for colored papers, but that the mills could increase their sales considerably by pursuing more aggressive promotional and educational programs.

Future advertisements in this series will discuss key specifying influences for colored paper, and how they can be influenced to use more of it. Be sure to look for them.



Both "PONTAMINE" Bond Canary G and "ZORON" WS were proven practical and valuable for commercial distribution on this miniature Fourdrinier paper machine in the paper service and development laboratory at Du Pont's Chambers Works.

Here, a group of experienced technicians and operators explores new uses for dyes, resins and chemicals; develops new color formulations; and investigates application problems and techniques.

news from Du Pont

NEW "PONTAMINE"* DYE GIVES BRIGHTER YELLOWS, HAS NON-TWOSIDED QUALITIES

"PONTAMINE" Bond Canary G now permits economical and easy dyeing of quality papers. It's one of the greenest and brightest of all direct yellow dyes, and has been especially developed by Du Pont Research for use on bond, writing, mimeograph, duplicator, envelope and other high-grade papers. In addition, this new dye is economical enough to be used for most other printing grades as well.

Compared to most other yellow dyes, "PONTAMINE" Bond Canary G has superior non-twosided qualities and provides a bottom color in a clay filled sheet. For more information, get in touch with a Du Pont Technical Sales Representative at the district office nearest you.

NEW RESIN FINISH GIVES DUPLICATING PAPERS HARDER FINISH, REDUCES LINT...PICKING

"ZORON"* WS, a surface applied synthetic resin, can be used with starch to surface-size paper and give it a harder finish. This quality makes it excellent for duplicating paper, since it materially reduces the amount of lint on the paper. As a result, these papers are less likely to clog up duplicating machines.

"ZORON" WS doesn't require aging of solution, and it remains stable in solution for at least 48 hours at size tub temperatures. Conventional mill equipment can be used to apply it. It has been proved highly practical on the Fourdrinier papermaking machine in the Du Pont Paper Laboratory.

For more information about this resin and its application to duplicating paper, write to the Du Pont district office nearest you.

*Reg. U. S. Pat. Off.

DU PONT
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DYES AND CHEMICALS

Better Things for Better Living
...through Chemistry

E. I. du Pont de Nemours & Co. (Inc.)
Organic Chemicals Department
Dyes and Chemicals Division
Wilmington 98, Delaware

SALES OFFICES:

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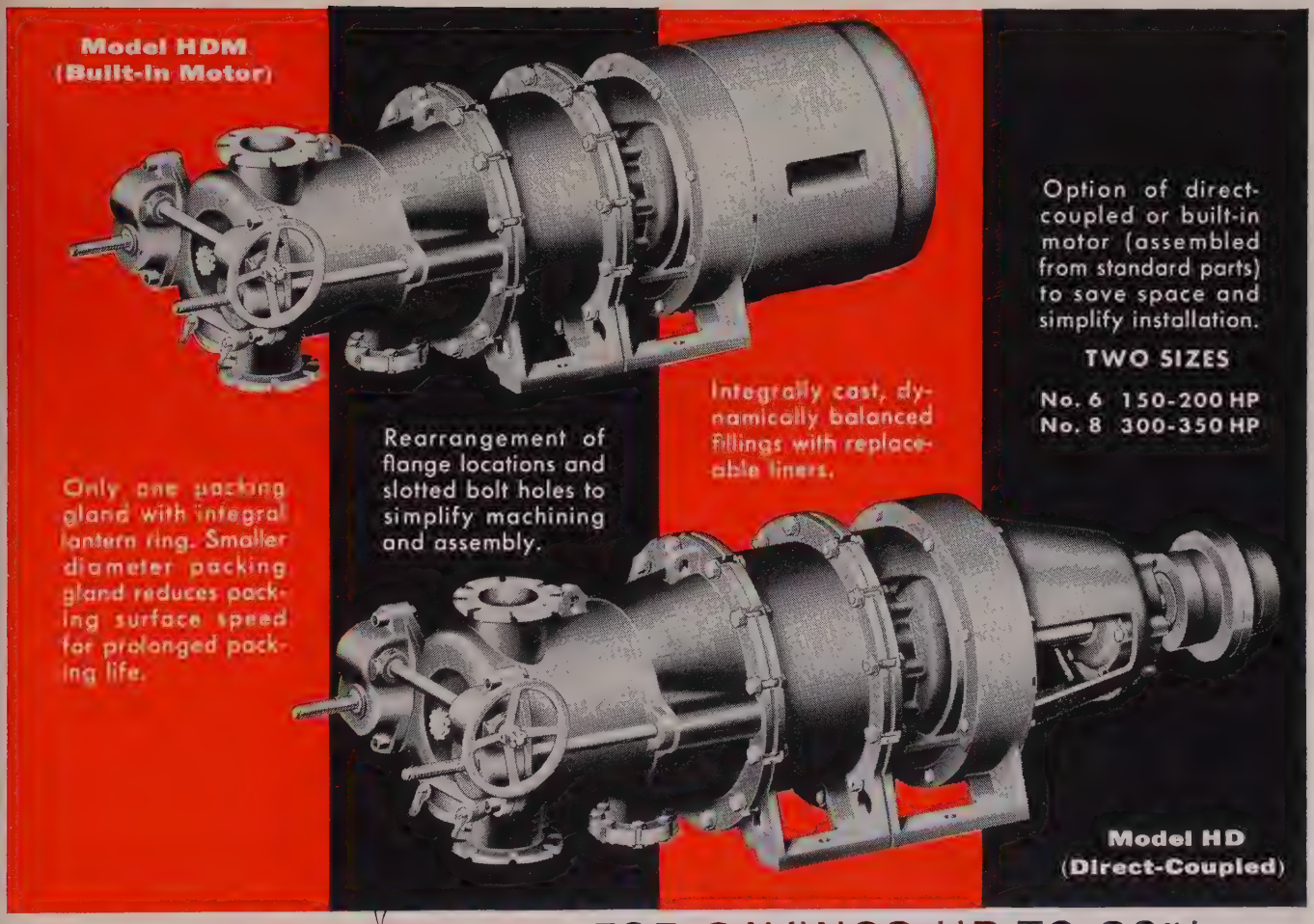
LOS ANGELES 58, CALIF., 2930 East 44th St.
NEW YORK 13, N. Y., 40 Worth St.
PHILADELPHIA 3, PA., 1616 Walnut St.
RUMFORD 16, R. I., 50 North Broadway
PORTLAND, ORE., 1238 N.W. Glisan St.

The NEW MORDEN

Morden's creative engineering, combined with the cooperative experience of nearly 300 paper mills using more than 1000 Morden refiners, brings you a completely new form . . . of the "Stock-Maker" and "Stuff-Maker."

These new machines are engineered to:

1. Further improve the "Stock-Maker's" reverse-flow, sealed-pressure beating treatment—so well proven through the last 25 years.
2. Retain the "Stuff-Maker's" straight-through-flow jordaning treatment—requiring only a simple filling interchange to give brushing or cutting treatment—now all in the same refiner housing.
3. Maintain Morden's high quality of materials, workmanship and performance—with savings of 20% in initial equipment and replacement filling costs.


Model HDM
(Built-in Motor)
Option of direct-coupled or built-in motor (assembled from standard parts) to save space and simplify installation.
TWO SIZES
No. 6 150-200 HP
No. 8 300-350 HP
Integrally cast, dynamically balanced fillings with replaceable liners.
Rearrangement of flange locations and slotted bolt holes to simplify machining and assembly.
Only one packing gland with integral lantern ring. Smaller diameter packing gland reduces packing surface speed for prolonged packing life.
Model HD
(Direct-Coupled)

INVESTIGATE NOW FOR SAVINGS UP TO 20%!

Ask for further description of the new "Stock-Maker" and "Stuff-Maker" and how they can benefit your operation. We shall be happy to visit you for an in-the-mill discussion of your requirements.

MORDEN
MACHINES COMPANY

3420 S.W. Macadam Avenue • Portland 1, Oregon

UNITED STATES REPRESENTATIVES—South: Brandon Sales, Inc., Greenville, South Carolina. **Midwest:** Dan B. Chapman, Appleton, Wis. **Northeast:** Orton Corporation, Fitchburg, Mass.

Educate Your Guesses—With Statistics

JOHN G. KRESSMAN

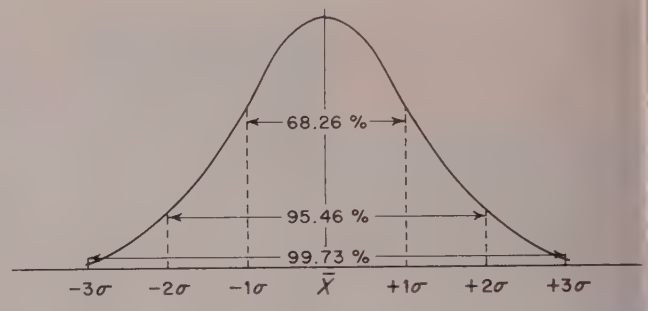
WEBSTER very aptly defines "statistics" as "the science of the collection and classification of facts on the basis of relative number or occurrence as a ground for induction; the systematic compilation of instances for the inference of general truths; or the doctrine of frequency distributions." Further, "induction" is defined as "the act or process of reasoning from a part to a whole, from particles to generals, or from the individual to the universal."

In general, conclusions reached by induction are probable only, as opposed to deduction in which the conclusion follows necessarily from the premise. In final analysis, statistics may be considered to be the science of probabilities. I hope to give you a layman's approach to same. It will be like religion in a sense, for in many instances you must have faith and take what I say at face value. Also like religion, you may have many questions later that I will be unable to answer—I am not an advanced mathematician or statistician, but a chemical engineer like a goodly portion of you in my audience.

Truthfully, all is not as high powered as this may sound. What I have to show you will be nothing more than what appears to be a common, horse-sense manner of handling information and data. I have a quotation that is credited to Darwin: "It seemed to me that there was a defect in the habit of thought of many in the engineering profession, and that some sort of campaign was needed to inculcate in their minds the idea that every number has a fringe; that it is not to be regarded as exact but as so much plus or minus a bit—and that the size of this bit is one of its really important qualities." It makes one wonder why it has taken so many years for this simple fact to come to life from the archives of the pure mathematicians and to take its place in the industrial world of today. Walter A. Shewhart, of Bell Research Laboratories, is generally considered the "Father" of industrial statistics in this country. As early as 1924, he realized the full value of the normal probability curve and began to use it for industrial application. His text published in 1931, "Economic Control of Quality of Manufactured Product," is still considered a reference bible today.

What was so remarkable about Dr. Shewhart's application? He fully appreciated that in industry as well as in nature, that variation existed—numbers did have a fringe. It might be some attribute of the raw material being used, some variation in the production process itself, some spread in the method of sampling or securing a representative sample, some "error" in testing technique, or some deviation in testing instruments. Whatever the source of variation, the important fact was that it did exist and did follow a normal pattern; so often that for practical use one may figure it to be ever true. (In the few cases where deviation from the normal does exist, it becomes statistically self-evident quite readily.) As important was the realization that change or shifts in this normal pattern must be caused by a real change within the system under consideration. One thus has the opportunity of discovering the cause for such change or variation, of correcting and oftentimes reducing the magnitude of same—literally the opportunity of replacing "art" with "science."

This normal pattern statistically is known as the normal frequency distribution curve, as illustrated by the diagram below.



The following table shows the area (per cent of material) from the center line to various values of standard deviation:

σ = Standard deviation	*Per cent of material, plus or minus*	*Per cent of material, plus and minus*
0.0	0	0
0.5	19.15	38.30
1.0	34.13	68.26
1.5	43.32	86.64
2.0	47.73	95.46
2.5	49.38	98.76
3.0	49.86	99.73
3.5	49.97	99.94
4.0	49.99	99.98
5.0	49.99	99.98

You will notice that the scale to cover the extent of this curve is not in absolute numerical figures, but per cent. The statistical unit used as a measure to define this scale is known as a Standard Deviation and is represented by the Greek letter sigma, σ.

In plain language, what does this frequency distribution curve tell us? For any occurrence or process (statistically called a universe) operating under a given set of conditions a natural amount of variation will occur. The total extent of this variation and the standard deviation or measure of internal variation may be computed. The average level of the values for the data under study may be determined. Approximately 68% of the recorded values will fall within $\pm 1\sigma$ limit of the average value, approximately 95% will fall within the 2σ limits, and 99.7% of all the values will fall within the 3σ limits. There is the opportunity for only 3 values per thousand to fall outside these 3σ

JOHN G. KRESSMAN, Technical Director, Continental Turpentine & Rosin Corp., Shamrock, Fla.

CALGON'S DISPERSIVE ACTION

NO CALGON—
there is no flow of the slurry containing low solids content
WITH CALGON—
the slurry flows readily with much higher solids content

most of the nation's
leading producers of coated papers

USE CALGON®

in their coating formulas . . . shouldn't you?

Calgon's special properties fit the needs of the paper industry. The experienced assistance of Calgon Technical Service has helped solve many a knotty water problem for paper manufacturers. Here are some of the reasons why so many of the nation's paper manufacturers chose Calgon for coating colors:

Better pigment dispersion. Calgon has high efficiency as a dispersive of clay, titanium dioxide, precipitated calcium carbonate, and other pigments.

Better coating colors. With Calgon in the formula, flow properties are improved and higher solids concentration can be used.

Better surface coating. Adding Calgon to the coating formula greatly improves the bond between the coating and the paper stock.

Calgon can help in many other ways. If you have a specific problem, Calgon Technical Service will be glad to assist you in finding a solution. Let us know about your problem, or write for a copy of "Calgon and Its Applications in the Pulp and Paper Industry."

Calgon is the registered trade mark of Calgon Company for its sodium phosphate glass (sodium hexametaphosphate) products.

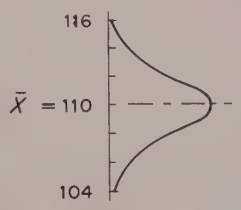
CALGON COMPANY
DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

limits without cause or change in the conditions of this universe under consideration. The statistician does not overlook the existence of these three chances per 1000; but they turn up so seldom as to be negligible for everyday work.

Let me give you a few examples which I think will illustrate some of these points:

1. Problem: You are making a 110 lb. per ream sheet on the average; the standard deviation for many runs over a long period of time has been computed to be 2 lb. per ream, thus a total variation of 12 lb. per ream exists. What distribution may be expected in a recent 100-ton lot?

Facts: There is no reason to believe the normal pattern will not continue; thus we have,



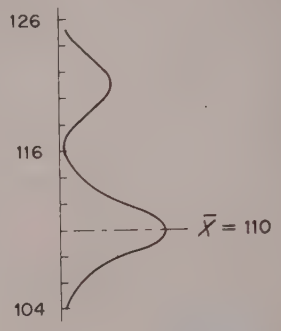
Solution: The average basis weight will be 110 lb. per ream. Deviation will occur both above and below this in the magnitude of:

Approximately 34 tons of the production ranging from 110 up to 112 lb. per ream
Approximately 34 tons of the production ranging from 110 down 108 \b. per ream
Approximately 13.5 tons of the production ranging from 112 up to 114 lb. per ream
Approximately 13.5 tons of the production ranging from 108 down 106 lb. per ream
Approximately 2.5 tons of the production ranging from 114 up to 116 lb. per ream
Approximately 2.5 tons of the production ranging from 106 down 104 lb. per ream

One would expect to find little if any paper over 116 lb. per ream or under 104 lb. per ream in the lot regardless of how much testing was done.

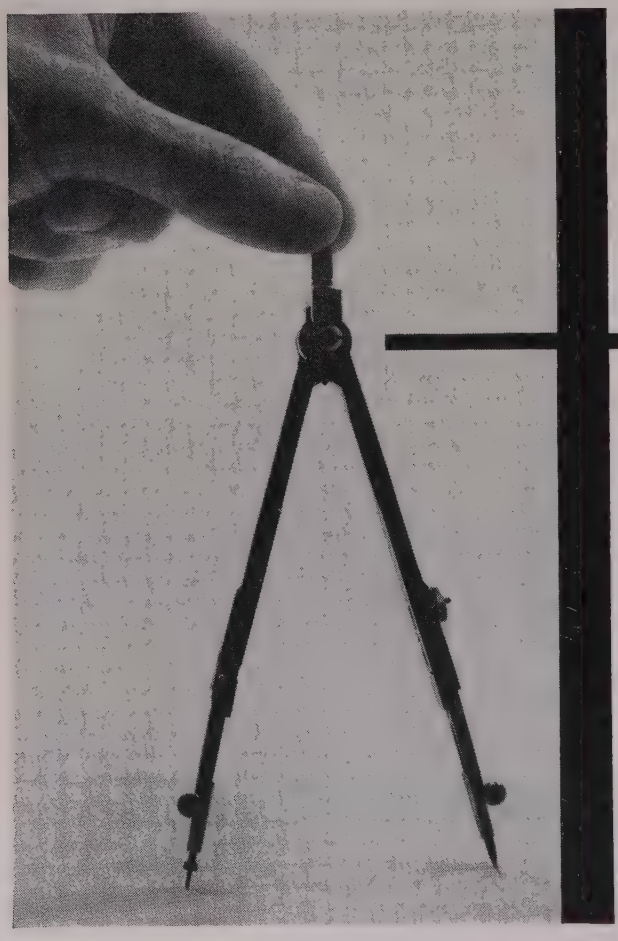
2. Problem: Presumably the above production is being maintained but control testing indicates that approximately 300 tons of the next 1000 ranges from 116 to 125 lb. per ream. What could this mean?

Facts: A detailed examination showed the distribution looked like this.



Solution: Some real causative factor has entered into the operation to shift its level completely. If you can define the cause, there is the possibility of eliminating the difficulty.

3. Problem: Our salesman is aggressive. The specifications on our 110 lb. per ream sheet gives a tolerance of ±6 lb. per ream. A customer declares he



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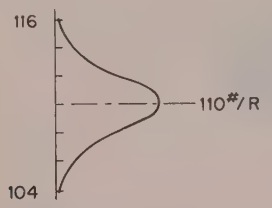
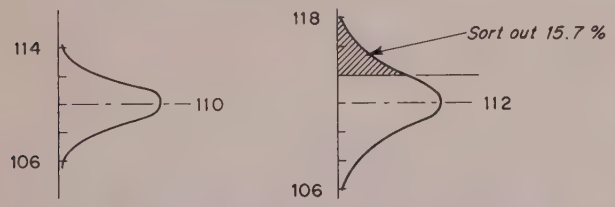
can tolerate a total variation of only 8 lb. per ream. The salesman thinks, what's a little matter of 4 lb. per ream, the production boys will be extra careful on this run and will come out O.K. He commits the company to the order. (He didn't realize the specs were set with realistic limits.) How can this run be most economically produced assuming the same degree of variation in the process as in problem no. 1? One suggestion has been made by the operating foreman to make the paper so that it will range from 106 lb. per ream, upward; thus, having only one end of the scale to sort out instead of both. Is this a wise solution?

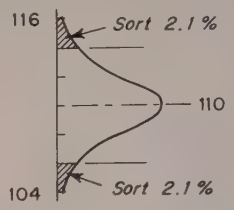
Facts: Our realistic operational picture looks like this:



The customer demands this, and to meet it a suggestion has been made to do this:



Solution: If the value of control testing follows the general pattern of being less costly than the produ itself, and if we consider that the out-of-spec bas weight product is to be reprocessed as broke, then t proper solution for least waste would be:



However, if the waste on the high side can be sold some other customer and not become broke, then t suggestion of the foreman to shift the level of the ope ating average may be wise. But, you have this lon range condition with such a solution—so long as yo sell paper by the pound you recover the extra cost shifting the average basis weight to a higher leve The customer however may be a converter on a price unit basis. In such case he will not produce as man units on the average from the heavier weight ream. he is smart enough to appreciate this (maybe he use statistics) and competition can supply a 110 lb. pe ream average sheet with ±4 lb. per ream variatio you will soon be forced to resort to sorting out bot ends of the waste to minimize the condition or to im proving your over-all conditions to change the level your operating characteristics to meet these ne limits.

The above problem shows one phase of statistics relation to setting specifications, here are two mo which are quite common.

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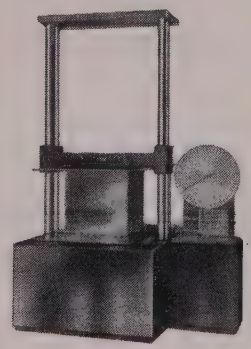

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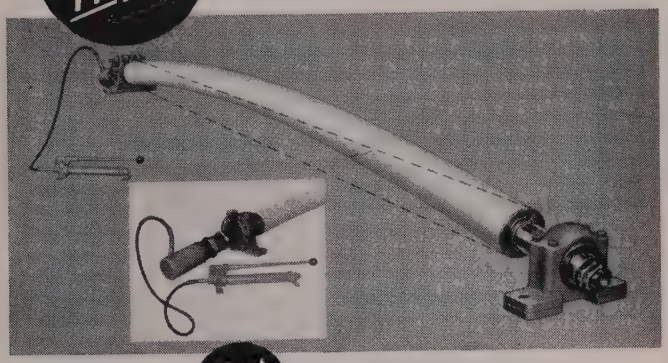

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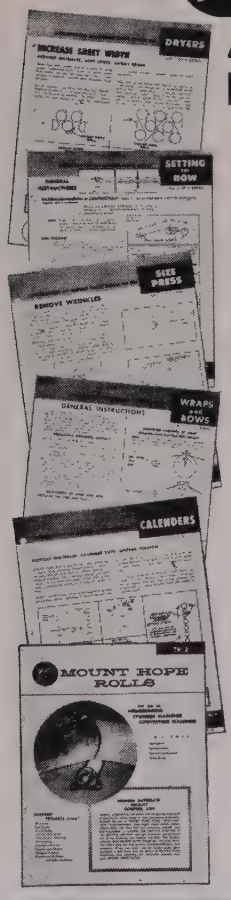

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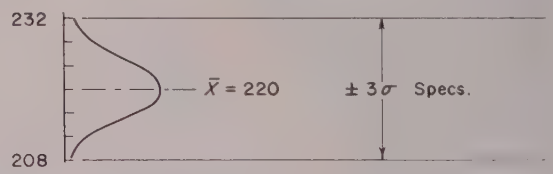
4. Problem: Our year's record shows that the 11[illegible] lb. per ream sheet has varied from 104 to 116 lb. pe[illegible] ream consistently, a standard deviation of 2 lb. pe[illegible] ream. The production department wants the sale[illegible] spec to be realistic and call for 110 lb. per ream, ±6 lb[illegible] per ream. The technical laboratory says, "phooey[illegible] why throw away our competitive advantage, make thi[illegible] specs 110 lb. per ream, ±3 lb. per ream." How is thi[illegible] possible?

Facts: The whole year's production pattern doe[illegible] show a normal distribution of 110 lb. per ream average[illegible] with 3σ limits of ±6 lb. per ream. Breakdown of th[illegible] year's production into proper periods by closer analy[illegible] sis of the technical laboratory shows that the total pro[illegible] duction is in fact made up of distinct periods where th[illegible] production has run with a 3σ limit of ±3 lb. per ream[illegible] but by the average's often shifting, a much wider tota[illegible] distribution was developed.

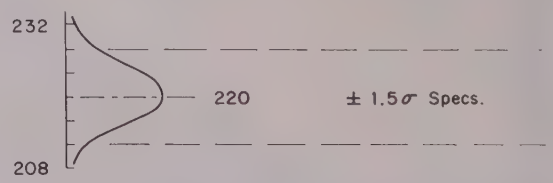
Solution: If the technical laboratory has as wel[illegible] discovered the cause for the shift and can eliminate it[illegible] or *if* control testing is adequate to pick up the shift[illegible] as they occur and proper adjustments can be made t[illegible] hold the narrow limits, then the narrow limits are[illegible] justified and it would admit to "sloppy" operations t[illegible] maintain the old wide limits.

5. Problem: As a result of a study of supplier's[illegible] capabilities (and many consumers are actually doin[illegible] this), a customer will accept a 220 lb. per ream board o[illegible] the average with a tolerance of 12 lb. per ream ± (a[illegible] standard deviation of 4 lb. per ream). The production[illegible] superintendent says: I can't tell my machine men they[illegible] can have a range of 24 lb. per ream to work in, they[illegible] would never make any good paper at all. I will just[illegible] cut the range in half and we will always come out with[illegible] good paper (his board machine did perform to the[illegible] accepted tolerance of ±12 lb. per ream but not sig-[illegible] nificantly better).

Facts: The machine's capability was:



The superintendent's orders were:*



In reality the final analysis of the production run was:

* To be accurate and correspond to the ±1.5σ. The dotted lines in the following figure should be spaced at midpoint of the 2σ space.

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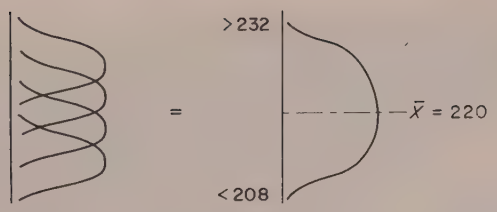

Solution: This is a typical example of overadjustment. The machine inherently must produce material in its $\pm 3\sigma$ limits of 24 lb. per ream. When it did, it was out of the superintendent's specs and adjustment was made. This changed the operational level to a new average, but maintained the same degree of normal variation. A wider over-all variation resulted than would have from leaving things alone. The best answer is to put on a control chart (more about this later) to tell when the machine is really out of its normal pattern; above all, be realistic in your limits.

There has been little difficulty so far in arriving at answers with the above problems, we have had the total historical data or information to develop the entire frequency distribution for evaluation. Suppose for reason of time (to make a run or produce a test), cost (to make a batch, ruin of the product by destructive sampling, complexity of equipment, etc.), mere magnitude (so much material is produced, too much tonnage, or so many pieces are produced to get a check of each item) or many other factors, we do not have the whole background of information. Here one naturally begins to make a decision on the information available; in reality, he must make an educated guess. There is nothing wrong with this process of reasoning, it must be used, but statistics will begin to tell you just how much you know and how much you are guessing.

Going back to my familiar example of 110 lb. per ream paper with a standard deviation of 2 lb. per ream, we have a frequency distribution of the proper values to give a normal pattern for 1000 reels. If I could write a value on a scrap of paper to represent each reel and throw it in a bowl, mix well, and then extract only one sample— which one would I get? Naturally I do not know; but I do know I would have approximately 680 chances to extract values between 108 and 112 lb. per ream, 270 chances to get values from 106 to 108 or 112 to 114 lb. per ream, and about 5 chances to get values of 104 to 106 or 114 to 116 lb. per ream. Knowing this, would you be willing to let the single sampling and analysis of one reel out of a thousand represent the whole lot? Naturally, no; but think how often this very act is done today. Or how often one fools himself with bias personal views, the first sample may be "poor" by not being what is wanted so a resample is taken. Because of sheer probability, the second, third, or some-where-along-the-line sample may be "good," it fits the preconceived value and suddenly the whole lot or process is considered to be O.K. Naturally, sampling is stopped at once, because you are satisfied.

If one sample is not enough, then how many are needed? I believe you will understand that this decision will tie in directly with the reliability or degree of precision with which you wish to define or estimate the particular quality or variable under investigation. The more samples you take, the nearer you come to having a true picture

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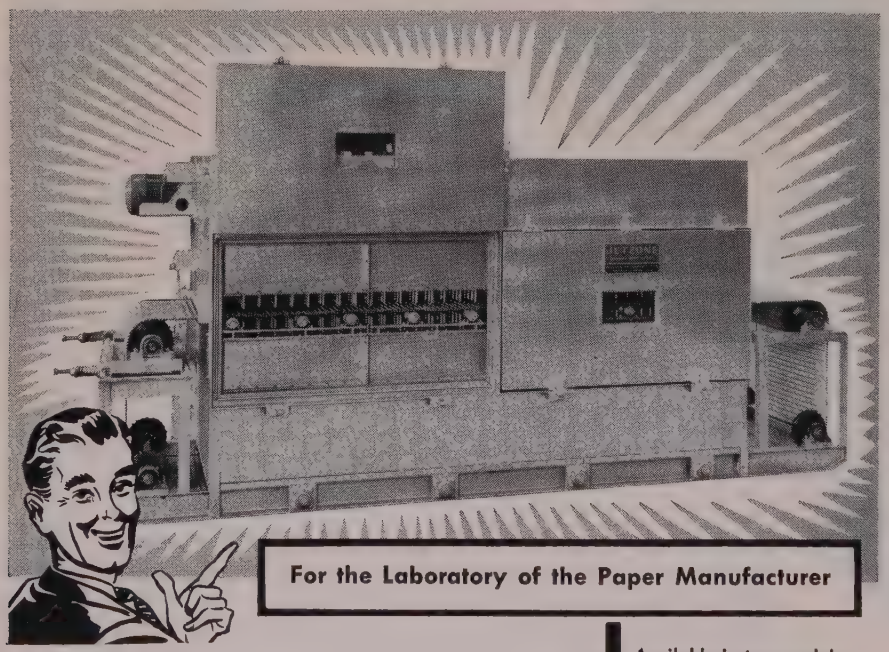

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of the frequency distribution of the lot. The subject of sampling is practically a course in statistics itself, reference books give precise data as to sampling requirements to meet various degrees of confidence limit. But as a rule of thumb for testing large lots (for example, to determine the diameters of the pulp logs in your wood yard, the variation per lineal foot of paper off a high-speed machine for mullen, tensile, etc., to get a chip size distribution to your digesters, and the like) the results of:

No. of random samples tested	*Information gained*
1	Very little with respect to average level or variation spread
5	A vague idea of average and deviation
10	A rough estimate of above
25	A fair estimate...
50	A fairly good estimate...
150	A good estimate...
250	An excellent estimate...
400 or greater	Nearly the same estimate as if the whole lot were tested

One need not plot a frequency distribution everytime data are collected, but for the beginner I can recommend nothing better to do. It is much like looking at a picture in *Life* instead of a page of data in the *Almanac*. Statistically we can compute the average by the common algebraic formula where:

$$\text{Average } X = \bar{X} = \frac{X_1 + X_2 + X_3 + \ldots X_n}{n}$$

where:

X = individual test value.
n = number of tests.

and the standard deviation of the random samples collected follows as:

$$\sigma = \sqrt{\frac{\Sigma X^2}{n} - \bar{X}^2} \quad \text{or} \quad \sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{n}}$$

where:

$\bar{X}$ = average of individual tests.
X = individual test.
n = number of tests.
Σ = summation (in other words ΣX^2 = the sum of all of the squares of the individual tests).

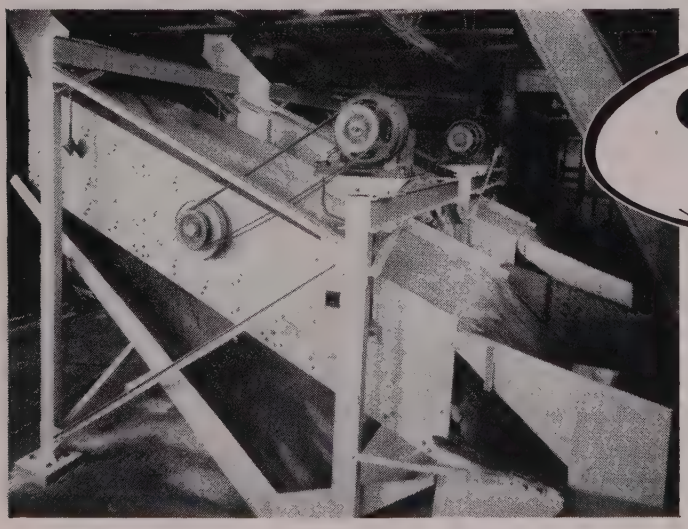
Note: Each formula will give the same numerical result, but at times it is more convenient to use one than the other so far as the computational work is concerned.

When the standard deviation of a lot or universe is computed with the above formula, particularly when using small samples, it will be smaller than the result obtained if the entire lot were tested. To correct for this the following formula needs be used:

$$\sigma' = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n - 1}} \quad \text{or} \quad \sqrt{\frac{\Sigma(X - \bar{X})^2}{n - 1}} \quad \text{or} \quad \frac{\sigma}{c_2}$$

where:

σ' = the expected or most probable standard deviation of the entire lot.
σ = the standard deviation computed from the random samples.
c_2 = a constant, which varies depending on the number of tests.
$X, \bar{X}, n$ = as defined above.



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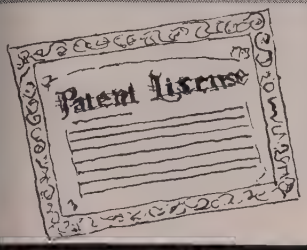

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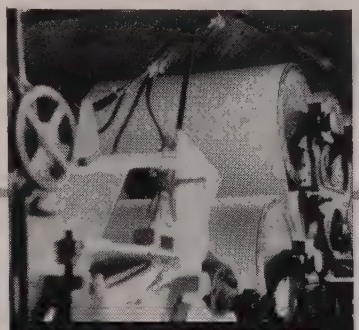

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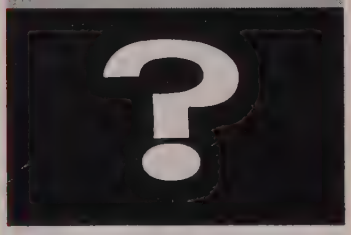

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SPECIAL COMMODITIES DIVISION
MINNEAPOLIS 26, MINNESOTA
General Mills

Table for values of c_2 (from Am. Std. Assoc., Z 1.3—1942, p. 39) When n =	Then, c_2 =
2	0.5642
3	0.7236
4	0.7979
5	0.8407
6	0.8686
7	0.8882
8	0.9027
9	0.9139
10	0.9227
11	0.9300
12	0.9359
13	0.9410
14	0.9453
15	0.9490
20	0.9619
25	0.9697

The spread between the minimum and maximum values of any test is called the range. This gives a reasonable estimate of the degree of variation for some work, but naturally is not nearly so accurate as the standard deviation. There is a constant relationship between the range and standard deviation when samples are drawn from the same lot or population. It follows:

$$\sigma = \frac{\bar{R}}{\bar{d}_2}$$

where:

R = max. less min. value in test group.
$\bar{R}$ = average of R's.
d_2 = a constant, which is related to the size of the test sample group.

Table for values of d_2 (same ref. as above for c_2) When n =	Then, d_2 =
2	1.128
3	1.693
4	2.059
5	2.326
6	2.534
7	2.704
8	2.847
9	2.970
10	3.078
11	3.173
12	3.258
13	3.336
14	3.407
15	3.472

If samples are drawn from the same population (or from a uniformly operated production process), there is a constant relationship between the standard deviation of individual tests and standard deviation of averages computed by grouping two or more individual tests together. This relationship is as follows:

$$\sigma_{\bar{X}} = \frac{\sigma_X}{\sqrt{n}}$$

where σ_X equals σ as shown above and the corrected standard deviation of the average is:

$$\sigma'_{\bar{X}} = \frac{\sigma'_X}{\sqrt{n}}$$

where:

σ'_X = σ' as shown above.
n = number of tests in group for averaging.

If we take a number of samples from a large lot of material (or uniformly operated production process), and compute the standard deviation (preferably returning those tested, if not destroyed), and then repeat the operation of measurement and computation

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without increasing cost

Because it is more efficient, Catalin Resin 301 . . . a modified, cationic urea-formaldehyde resin . . . can substantially upgrade wet strength with the same percentage of resin solids previously used . . . or cut resin costs by maintaining present wet strength properties with less resin solids. You gain in other ways too . . . Catalin Resin 301 is lighter in color . . . and reacts exceptionally well in the presence of dyes. Dry tensile, mullen and folding endurance is also improved.

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with other samples, and repeat again and again, we will find that there is some variation in the standard deviation. We usually think in terms of the standard deviation computed for the individuals or of average results as a measure of variation. However, we also may use the standard deviation of the standard deviation as a measure of variation. This is computed as follows:

$$\sigma_\sigma = \frac{\sigma}{\sqrt{2n}}$$

or for the corrected standard deviation:

$$\sigma'_{\sigma'} = \frac{\sigma'}{\sqrt{2n}}$$

where values are as previously defined.

When probability or frequency distribution curves are plotted with standard deviation rather than actual value as the ordinate, the same type of normal curve is practically always obtained with about the same proportion of tests almost always within definite limits of standard deviation. If the shape of the distribution is reasonably normal, approximately two-thirds of the tests will be within $\pm 1\sigma$, approximately 95% will be within $\pm 2\sigma$, and practically all tests will be within $\pm 3\sigma$. Even if the distribution is definitely not normal, at least 75% must be within $\pm 2\sigma$, and at least 89% within $\pm 3\sigma$. This fact is the basis for all control chart work.

Now you find out what I have really been leading up to with all this discussion on standard deviation—quality control charts, probably the most "heard-of" phase of industrial statistics; and, in addition, the not so well known tests for significant differences for averages ($\bar{X}$'s), and for degree of variation (σ's).

I can best explain a quality control chart by giving you an idea of how one is constructed and how it effectively operates. First we have a process which through historical checking has shown to run fairly uniform, a paper machine for instance. If we had sampled it frequently over a period of time we could build up sufficient information to plot a frequency diagram of the variable in question; let us use basis weight to get the average value and the standard deviation. But this is all past history, what we really want now is something to check the present or current production. A control chart does this very thing, using the past information (usually, but sometimes a standard or specified value is used for comparison) as the basis for comparison of the current activity. If the old testing has been done with replication, each test group may be averaged to give $\bar{X}$ and the range may be computed to give R (or we could compute sigma). When enough of these tests are available to give a fair estimate of performance, then the control chart may be established, where:

The $\pm 3\sigma$ control limits for $\bar{\bar{X}} = \bar{\bar{X}} \pm A_2\bar{R}$

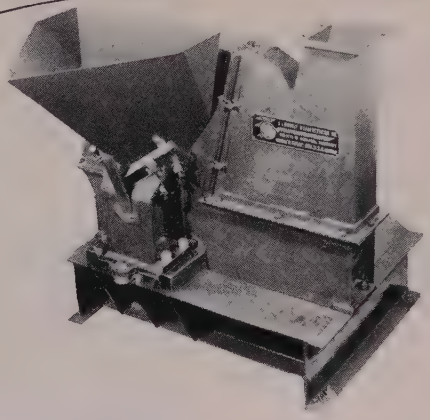
where:

X = individual test.
$\bar{X}$ = average of each test subgroup.
$\bar{\bar{X}}$ = average of the $\bar{X}$'s.
R = range, each subgroup.
$\bar{R}$ = average of the R's.
A_2 = constant which varies with size of subgroup of n observations.

The $\pm 3\sigma$ control limits for $R = D_4\bar{R}$ and $D_3\bar{R}$

Reclaim OVERSIZE CHIPS

Murco Rechippers



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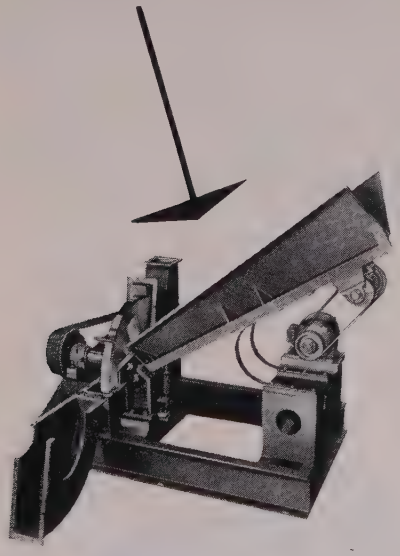

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CAPACITY 700-800 cubic feet of chips per hour.
DISC 40" diameter x 2" thick steel plate provided with blower vanes and renewable wear plates . . . DISC SPEED 870 RPM . . . SPOUT SIZE 8¾" x 8¾" . . . MOTOR 51 HP, 870 RPM TEFC Induction Motor . . . BLOWER HOUSING ¼" steel plate . . . OVERALL SIZE — 4'0" x 6'9" x 4'0" . . . BASE — Cast Iron with extension for the direct connected motor . . . NUMBER OF KNIVES — 6 size ⅝" x 4¼" x 12" lg. Alloy Steel . . . SPOUT LINERS — Replaceable steel plate, hard surfaced . . . COUPLING — Flexible . . . SHAFT — High carbon steel . . . BEARINGS — Spherical roller bearing pillow blocks . . . WEIGHT — 3000 lbs. including motor.

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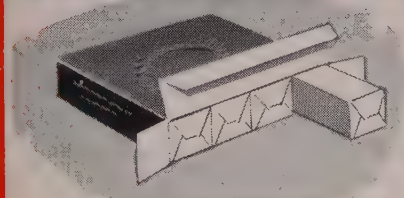
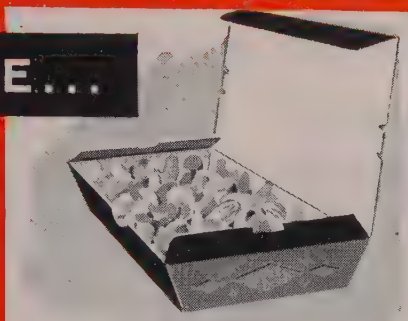
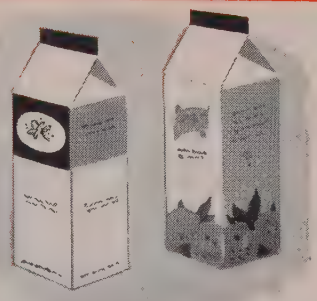


BUTTER, OLEO

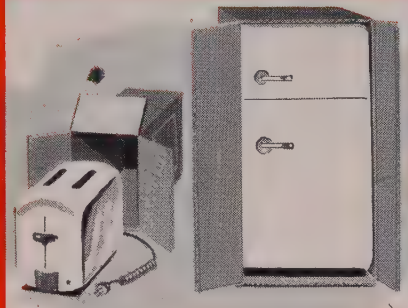


NUT MEATS

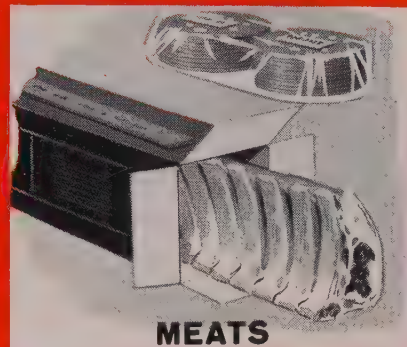


MILK, JUICE

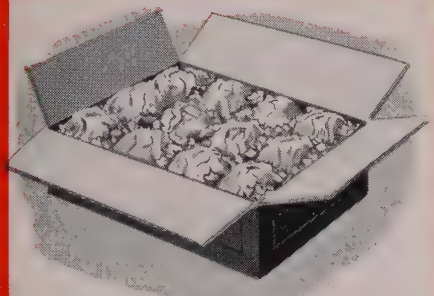
FURNITURE



APPLIANCES



MEATS



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If grease, moisture or fine finishes present packaging problems for your product, here's how you can pack and ship them safely *without recourse to costly carton liners:*

Incorporate A-C Polyethylene into your present carton-coating operation! It will eliminate fiber scratch and scuffing, give your cartons adequate resistance to grease, water and chemicals.

A-C Polyethylene can save you money, too. When you add it to ordinary wax coatings, *penetration is drastically reduced,* resulting in less wax consumption. For example, with straight paraffin, the normal coating weight is 7-8 lbs./1000 sq. ft. With addition of A-C Polyethylene, *it is frequently reduced to 3-5 lbs./1000 sq. ft. with superior protection!*

Write for literature, free samples. Free samples and technical data are now ready for your evaluation. Just write us at the address below. Or ask your local Semet-Solvay representative for a demonstration in your own plant. He can show you, right on your own equipment, how A-C Polyethylene can improve your cartons, save you money at the same time! *Contact us for the names of processors in your area who make up blends of A-C Polyethylene and wax.*

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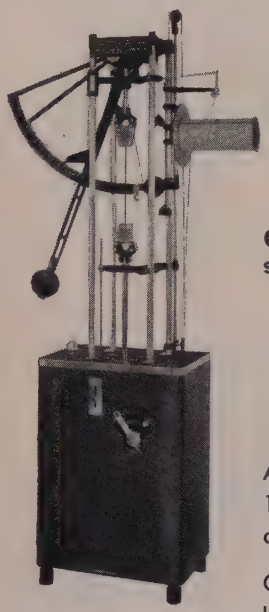

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where D_3 and D_4 are constants varying with the size of the subgroup, of n observations.

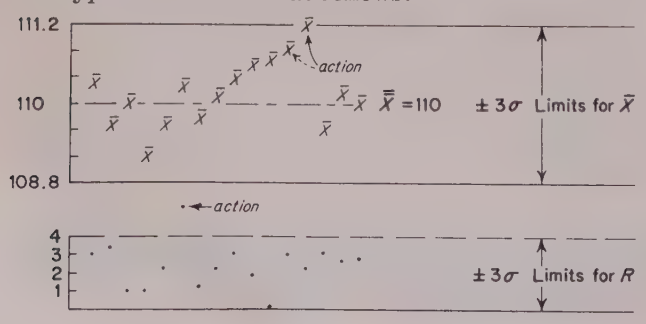
Tables for (from Am. Std. Assoc. Z1.3—1942, p .39):

n	A_2	D_3	D_4
2	1.880	0	3.268
3	1.023	0	2.574
4	0.729	0	2.282
5	0.577	0	2.114
6	0.483	0	2.004
7	0.419	0.076	1.924
8	0.373	0.136	1.864
9	0.337	0.184	1.816
10	0.308	0.223	1.777

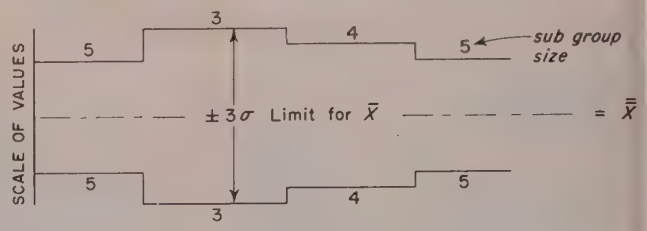
Note: For samples of more than 10 observations, the range is not recommended since it becomes rapidly less effective than the standard deviation as a detector of assignable causes as n increases beyond this value. For such cases use control charts for $\bar{X}$ and σ.

It is customary to plot the chart for $\bar{X}$ above that for R. Since the record is usually kept as a chronological record of some production process, it may be right at the machine to best control the operation itself.

A typical chart looks as follows:



It is convenient to keep the sample subgroups the same size if at all possible in control chart work for the ±3σ limits will change in numerical value with change in subgroup size (because of the factors one must use in the formula). If they do change it will give a chart that makes the limits expand or contract the appropriate amount, but will not reduce the reliability of the data (beyond the inherent probabilities that not as much information is gained from subgroups of two samples as from those of five, or better, from 10). Your chart would show the following type of effect with the changing subgroups:



One may ask, how many subgroups are needed to gain the necessary information to begin a control chart? The answer again ties in with just how good a chart you want, how well do you want to control. The following rule-of-thumb figures may assist you.

No. of tests of, subgroup size, n = ?	*Action for control chart*
5	Too few but, if you have to start a chart, compute the limits but do not use for strict "take action" purposes
10	Take your first five plus the second five and recompute the limits. Watch your operation but use only as a guide and not for "take action"
25	Probably the lowest number for valid computational work on limits meaningful for take action
Over 25	Analyze and recompute your limits with sufficient regularity to assure that the degree for good control is not changing nor the level shifting.

There is often the problem of building up subgroups of five (or 10) due to the slow nature of the process, cooking time of a digester for instance. A method which can be used to advantage is to use a running average for the subgroup. Take the first five tests, average; when the sixth test comes up, drop the first and combine the last with the remaining four, average; when the seventh comes up, drop 2, combine, average; etc., etc. This method has a tendency to slow down the trend of change, but when and if it does occur, it is all the more significant in a sense.

The statistical control chart does almost more than any one other item to stabilize a production operation. It takes the guesswork out of when-to and when-not-to make adjustments. It supplements "art" with "science" and "intuition" with "fact."

The statistical tests for significance of differences in average level, $\bar{X}$'s, and in standard deviation or extent of variation, σ's, are of great assistance in making a factual decision or admitting it is a guess. They are again based on the principle of normal distribution, and the probability of duplicate occurrence of comparative groups of data. The mathematical statisticians have assembled all of this in tabular form to indicate whether such would happen 1 time in 10 times, 1 in 20, 1 in 50, 1 in 100, or 1 in 1000. Generally significant

New Nalco Coagulant makes Larger, Heavier Floc . . . Faster

Radically different Nalcolyte 110 used with Conventional Chemicals to Cut Costs, Speed Action in Water Clarification

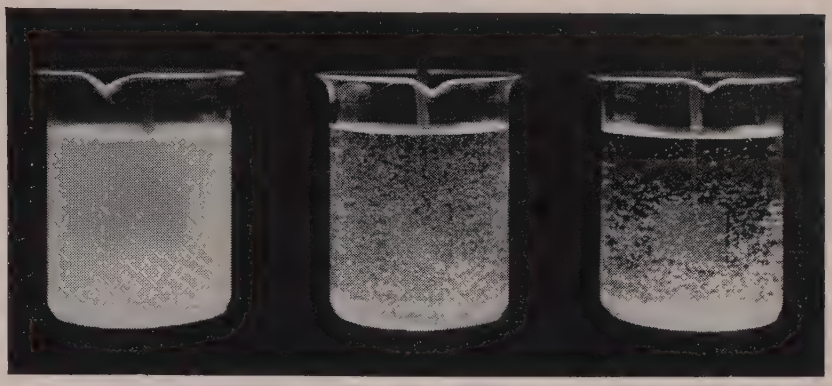


Photo taken in Nalco Laboratories 7 seconds after agitation stopped: *Left*, Control sample of untreated turbid water; *center*, same water, treated with 50 ppm alum; *right*, same water, treated with 20 ppm alum, 1 ppm Nalcolyte 110. Note that large, dense floc is settling out much more rapidly than center alum-treated sample.

Nalcolyte 110 is a new, non-ionic high polymer flocculant of very high molecular weight—over 1,000,000. It is used in extremely small dosages with conventional coagulants (such as sodium aluminate, alum, ferric sulfate) to increase size, density and uniformity of floc.

Less Chemical; Greater Capacity

Action of Nalcolyte 110 in creating heavier, larger, faster-settling floc not only permits greater throughput rates without floc carryover to processing equipment, but also cuts the total chemical requirements at a resultant cost saving.

In the example illustrated above, only 40% as much alum is required when Nalcolyte 110 is used.

May be Used in Potable Waters

Approved by the U. S. Public Health Service Technical Advisory Committee for use in treatment of public water supplies, Nalcolyte 110 gives water works the opportunity to get appreciably greater capacity from existing clarification equipment—at lower treating cost.

High Suspended Solids No Problem

Waters containing high suspended solids respond quickly to Nalcolyte 110 coagulating action . . . frequently without other coagulant chemicals.

Typical high suspended solids waters which can be treated with speed and economy with Nalcolyte 110 are paper mill white water systems, industrial waste waters, mineral slurries and blast furnace gas wash water slurries.

Nalcolyte 110 Easy to Handle

Nalcolyte 110 is a coarse, white, free-flowing powder of non-toxic character. It is fed in dilute water solutions with standard liquid proportioning pumps or feeders. Stock solutions are prepared at concentrations up to 20%. Packaging is in convenient 25-lb. bags.

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Full information on Nalcolyte 110 for your coagulant use is ready to be sent upon your request. Write today, or call your Nalco Representative.

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differences are not assumed to exist until the probability of occurrence by random chance alone is less than 1 time in 100.

The "t" test for significant difference in averages assumes several arithmetic forms:

1. Simon's formula where:

$$\frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{\sigma'_{\bar{x}_1}{}^2 + \sigma'_{\bar{x}_2}{}^2}} = \begin{cases} >3, \text{ indicating a significant difference} \\ 2\text{–}3, \text{ doubtful range as to whether difference is real} \\ <2, \text{ no significant difference} \end{cases}$$

Where $\bar{X}$ and $\sigma'_{\bar{X}}$ are as previously defined.

A. Example: Two different basis weight scales, known to be in good agreement, report the basis weight of a run of paper off the same machine to be:

Testing Machine A, lb. per ream	*Testing Machine B, lb. per ream*
231	227
230	231
233	240
236	232
232	233
235	220
230	221
236	220
227	225
223	229
$\bar{X} = 231.3$	$\bar{X} = 227.8$

Has the machine truly shifted average level of basis weight?

Solution: By computation to arrive at the corrected standard deviation of the average:

$$\sigma'_{\bar{x}_A} = 1.31 \qquad \sigma'_{\bar{x}_B} = 2.08$$

then,

$$t = \frac{|231.3 - 227.8|}{\sqrt{1.31^2 + 2.08^2}} = 1.42$$

Conclusion: Such a group of data could occur too often by random chance alone to be significantly different.

2. To determine if there is a significant difference between an average and a standard value:

$$t = \frac{|\bar{X} - E|}{\sigma'_{\bar{x}}}$$

where $\bar{X}$ and $\sigma'_{\bar{X}}$ as previously defined and E is the standard expected value.

B. Example: The average cross machine tear for a paper that a converter uses is 140%. You submit samples from five different rolls that show 130, 120, 135, 141, and 132%. Is your paper so inferior as not to be competitive?

Calculation:

$$\bar{X} = 11.6 \ (X\text{'s are coded} = X - 120)$$

$$\sigma' = \frac{6.89}{c_2} = 8.19$$

$$t = \frac{|11.6 - 20|}{8.19/\sqrt{5}} = 2.29$$

Conclusion: In referring to the critical tables for t (in Statistical Tables for Biological, Agricultural, & Medical Research, R. A. Fisher and F. Yates) we find that this condition can happen between 1 per 10 and 1 per 20 times by sheer chance happening alone by selecting random samples from such a universe, thus *no* significant difference may be assumed. (I hope the customer uses statistics or else you may have a hard time proving it—more samples would do it one way or another; it could be worse or just as good.)

C. Example: Paper from a certain mill over the past several months has had an average mullen strength of 48% with a σ of individual rolls = 4. The average mullen of the last carload of 50 rolls is 55%. Does this indicate the mill's process has improved or is it most likely due to be a chance variation?

Calculation:

$$\sigma'_{\bar{x}} = \frac{\sigma'}{\sqrt{n}} = \frac{\sigma/c_2}{\sqrt{n}}$$

where c_2 approximates 1.

$$t = \frac{55 - 48}{4/\sqrt{50}} = 12.36$$

Conclusion: In tables for t, we find that this event could happen less than 1 time in 1000 by random chance alone, thus we are willing to assume a significant change.

D. Example: Suppose the above shift had been to 50% instead of 55%. Significant?

Calculation: $t = 3.54$.

Conclusion: Critical tables show this still to be a chance occurrence in the magnitude of 1 to 1000 times, thus we assume a significant change.

E. Example: Suppose the original shift to 55% had been based on 5 instead of 50 tests. Significant?

Calculation: $t = 3.91$.

Conclusion: This could now occur some place between 1 time in 50 and 1 time in 100; a significant change is suspect, but not nearly so assured as with the 50 tests.

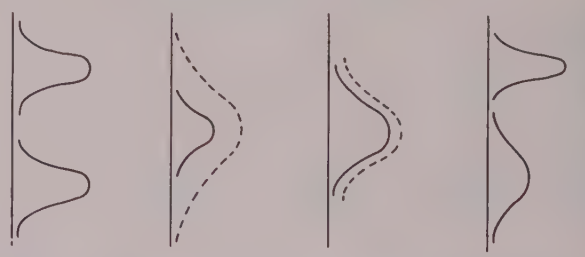
F. Example: Suppose the shift to 50% as shown to be significant on 50 tests had been only on 5 tests. How significant?

Calculation: $t = 1.14$.

Conclusion: This could occur more often than 1 out of 10 times by random chance; thus *no* significant difference can be assumed.

I am sorry I cannot devote more time to the other variations of the t test, which have equally important and interesting applications.

Where the t test is used for differences in averages, the f test is used for significant differences in distribution or variation. To truly compare for similarity between two groups, both tests should be used for you may have the following conditions:



Different t Same f | Same t Different f | Same t Same f | Different t Different f

The f test formula is:

$$f = \frac{\sigma_1'^2}{\sigma_2'^2}$$

where $\sigma_1' > \sigma_2'$ for n_1 and n_2 tests, n_1 may be $\lessgtr n_2$.

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FULL-FLOATING ALUMINUM BEARINGS
Roll with the punch of each stroke to distribute load

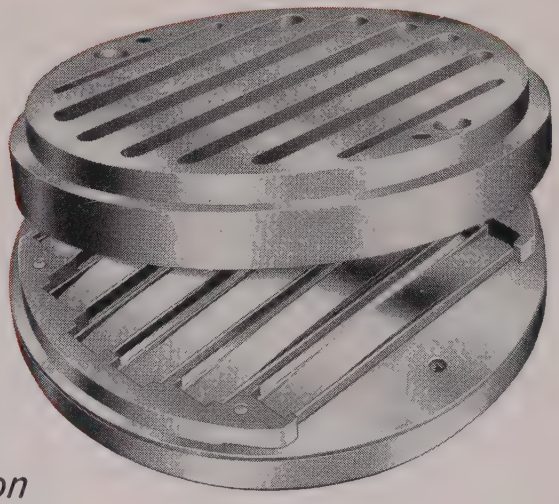
SEALED FRAME
Keeps dirt out • Keeps oil in
Keeps wear down

AIR-CUSHIONED CHANNEL VALVES
Highest efficiency • Exceptional durability • Quiet operation

FULL FORCE-FEED LUBRICATION
Filtered oil under pressure to all bearing surfaces

these EXTRA-VALUE FEATURES mean top performance and economy

take CHANNEL VALVES for example...



exclusive air-cushioned action means long life, high efficiency and quiet operation

The air-cushioned I-R Channel Valve is the greatest advance ever made in compressor valving, and is entirely different in principle and design. No other valve can approach its efficiency, quietness and almost unbelievable durability. The Channel Valve has eliminated the major problem of impact, without using heavy parts which kill efficiency or frail elements which soon break or wear out.

The Channel Valve is actually a combination of several small valves — each channel with its bowed leaf spring operates individually over a corresponding slot-shaped port. The channel lifts straight up in the guides without flexing; opening is uniform over the full length of the port, giving uniform air velocity without turbulence. The cushioning takes effect when a small volume of air is trapped between the channel and its leaf, causing the channel to float silently to a stop.

Channel Valves are a product of Ingersoll-Rand's own valve research and manufacturing departments, and constitute only one of the quality features which have given the I-R compressor line its reputation for excellence. For more information about compressors for any service, from ½ to 7500 hp, call your I-R representative.

ESH
20 to 150 hp.

PHE
75 and 100 hp.

XLE
125 to 350 hp.

PRE
400 to 2000 hp.

XPV
200 to 1500 hp.

IR

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A. Example: It is known that for a proper consistency of surface coating paste, a viscosity uniformity of $\sigma' = 50$ must be maintained. Five lots of paste mixed by a new operator have viscosities of 575, 680, 425, 605, and 390 cp. Do we have reasonable evidence to present to the union for removal of this man from the job for too much variability in his work?

Calculation:

X	Coded $X = (X - 400)$	X^2
575	175	30,625
680	280	78,400
425	25	625
605	205	42,025
390	−10	100
	$\Sigma X = 675$	$\Sigma X^2 = 151,775$

$$\sigma_1' = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n-1}} = \sqrt{\frac{151,775 - \frac{(675)^2}{5}}{4}}$$

$$\sigma_1'^2 = 15,162 \ @ n_1 = 5 \qquad \sigma_2'^2 = 50^2 \ @ n_2 = \infty$$

thus:

$$f = \frac{15,162}{2500} = 6.05$$

Conclusion: In critical tables for f, variance ratio, from same reference as t; this combination of results could happen less than 1 time in 1000 by random chance alone, thus a significant variation is presumed to exist.

B. Example: Changes have been made on a paper machine which ran consistently with a σ' of 4 lb. per ream, after 10 tests we compute a $\sigma' = 2.5$ lb. per ream. Have we made real improvement?

Calculation:

$$f = \frac{\sigma_1'^2}{\sigma_2'^2} @ \begin{matrix} n_1 = \infty \\ n_2 = 10 \end{matrix}$$

$$f = \frac{4^2}{2.5^2} = 2.56$$

Conclusion: From critical tables, this variation could occur 5% of the time (1 chance in 20); *no* change can be assumed.

C. Example: We believe from all background information (technical knowledge, intuition, and educated guesses) that the above change is in the right direction. If it can be proved true, we will have an edge on competition and a real quality improvement. More testing is deemed advisable. For easy comparison let us assume, after a result of 50 tests we find σ' continues to be 2.5 lb. per ream, and when the data were further analyzed the 2.5 lb. per ream variation at 25 tests prevailed as well. (Actually the standard deviation would change with more testing.) What is our decision now as to significance in the degree of variation?

Calculation: We still have $f = 2.56$. But, at $n_1 = \infty$, $n_2 = 25$, a real difference is indicated at the 1% (1 time in 100) level of significance. Further, at $n_1 = \infty$, $n_2 = 50$, a real difference in variation is indicated at the 0.1% level (1 time in 1000) of significance.

Another significance test that has useful application is the chi square test to determine whether there is a significant difference between the observed frequency and the expected frequency of occurrence.

Formula: $$\chi^2 = \Sigma \left[\frac{(O - E)^2}{E}\right]$$

where:

O = observed frequency.
E = expected frequency.

Note: When O is greater than E, subtract 0.5 from 0. When O is less than E, add 0.5 to 0. Chisquare test should *not* be used if $E<5$.

I shall not go into the arithmetic computation involving the use of this formula; it is not difficult, but tricky, and not so straightforward as the above might appear. Again, the statisticians have computed probability tables which enable us to make an educated guess as to the degree of significance by the expectancy of chance occurrence of comparative data. For instance:

A. Example: We know that a certain paper for day-in-day-out test passes a certain fold endurance level, with an average of 10% failure. We have sampled 50 rolls in one lot and find only one failure. Do we have good assurance this lot is superior to the average production?

Calculation:

Defective			Good		
O	E	$O - E^a$	O	E	$O - E^a$
1	5	3.5	49	45	3.5

[a] Corrected value.

$$\chi^2 = \frac{3.5^2}{5} + \frac{3.5^2}{45} = 2.73$$

Conclusion: In referring to tables for χ^2 (same reference as for t tables) we observe that if the 50 rolls did in reality contain 10% failure stock, that this occurrence of one failure could happen about 1 in 10 times; thus, *no* difference is assumed from the average.

B. Example: We have used two different makes of the same type of bearing: Out of 50 of type A, 3 failed; out of 75 of type B, 15 failed. Is there conclusive evidence to cut off supplier B?

Calculation:

	Defective			Good		
	O	E	$O - E^a$	O	E	$O - E^a$
Type A	3	7.2	3.7	47	42.8	3.7
Type B	15	10.8	3.7	60	64.2	3.7

[a] Corrected value.

$$\frac{18}{125} = 14.4 \text{ Av. \% defective}$$

$$50 \times 14.4 = 7.2E_A$$
$$75 \times 14.4 = 10.8E_B$$

$$\chi^2 = \frac{3.7^2}{7.2} + \frac{3.7^2}{42.8} + \frac{3.7^2}{10.8} + \frac{3.7^2}{64.2} = 3.69$$

Conclusion: In referring to the tables, we find that such occurrence, hard as it may seem, can exist from random chance alone someplace between 1 time in 10 and 1 time in 20. There may be slight indication of a difference at this point, but far from conclusive evidence. Further testing and recomputation of the data might give a decisive answer.

Thus far the information may appear to have been slanted more toward the production and control side of the picture. The statisticians more and more are putting emphasis on aids for experimentation and research, for here is where new facts must be found to translate back to production—to reduce variation, to better quality, and to maintain the never ending circle of advancement toward the optimum of any process. One of the more simple statistical tools used for ex-

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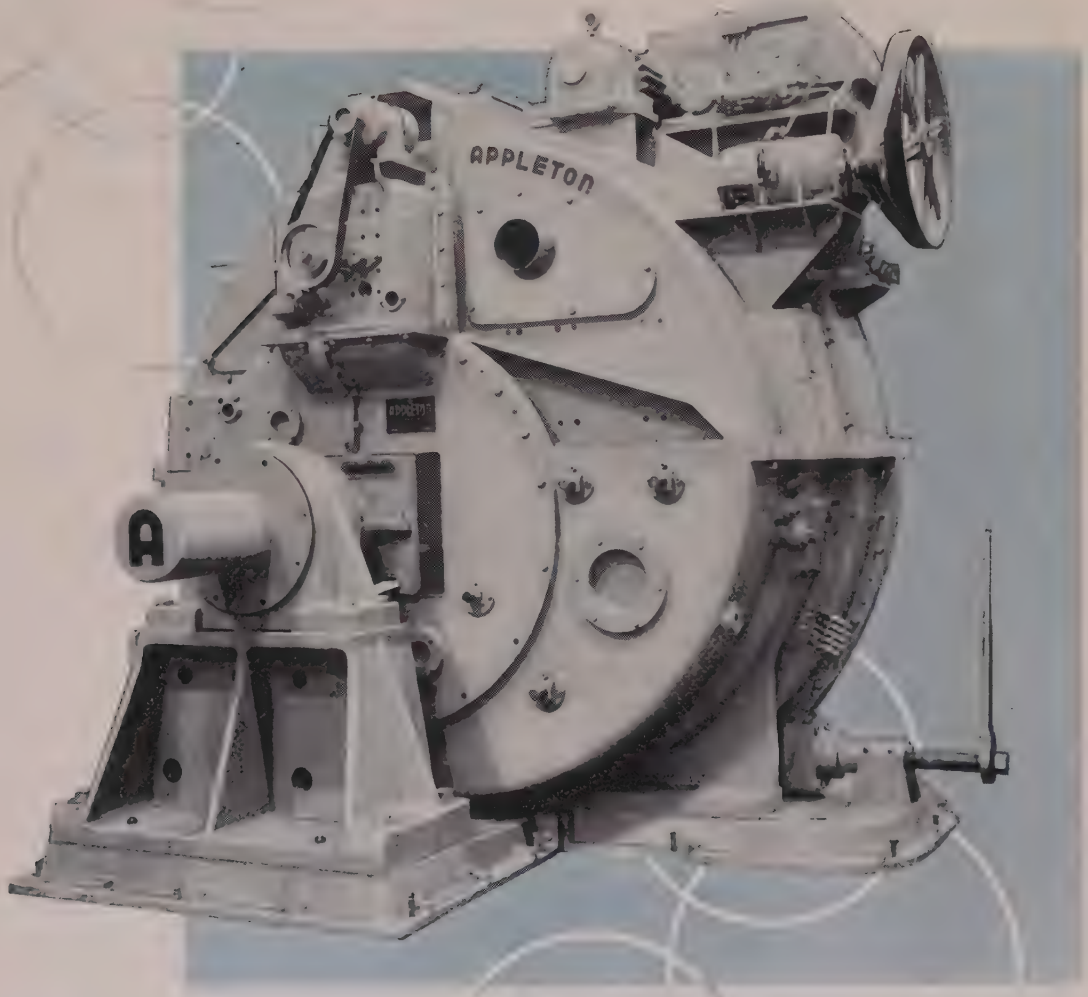

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perimental work is known as the variance analysis. Here one considers several variables for study, preferably not more than three or four at one time (because of the time involved to complete the experimental series, not to mention the arithmetic complexity for final computation). To show you an extreme case I quote in part from a memo I once wrote to my research director, in a former position, concerning a test which one of my colleagues (not familiar with statistics) had set up and was considering carrying out: "I happened to see an outline which Mr. X has prepared on coating and coater variables. He has listed items which are important, to his thinking. All told, if the test were run in full, without replication (duplicates) and 10 min. allowed per sample specimen group for running and collection of data—over 2,000,000 samples would need be run; or expressed in terms of 40-hr. weeks, at 50 wk. per yr., Mr. X would need to live to be 200 years old to complete it."

Through background knowledge, prior investigational work, pure guess, or otherwise, different levels or degrees of test are assigned each of the primary variables to be studied. Then each level is tested against the other so that one may determine not only the amount of variation assignable to the prime variables, but in addition, the amount of variation caused by interactions of one variable with another, or as a whole group. This latter condition can never be determined by the old classical method of testing one variable at a time and holding all others constant or "randomized."

I can best illustrate by an example: You have two laboratory technicians, John and Henry; two mullen machines, one hand operated and the other power operated; and several grades of paper, 110, 150, and 220 lb. per ream on which to maintain tests. Can you be assured that the results of data are fully interchangeable regardless of the combination of variables, or is there a significant difference in variability?

Prime variables	*Levels of variation*	=	*No.*
Laboratory technicians	John Henry		2
		×	
Mullen tester	Hand operated Powered		2
		×	
Grades of paper, lb./ream	110 150 220		3
	Total tests without replication		12
		×	
Each test to be run with 6 "pops"			6
		×	
On three different days			3
	Total pops required		216

EXPERIMENTAL PLOT

Lab. Tech.	JOHN						HENRY					
Machine	HAND			POWER			HAND			POWER		
Paper	110	150	220	110	150	220	110	150	220	110	150	220
DAY 1												
DAY 2												
DAY 3												

Final computation of the foregoing experiment will show the degree of significance in variation assignable to:

Laboratory technician, Mullen tester, Paper weight } Primary variables
Technician × machine, Technician × paper, Machine × paper, Technician × paper × machine } Interactions
Residual: internal variability of the test; this can be so great as to show none, or part, of the above to have any significance under the conditions of test.

Often times only two variables may be under consideration and the remainder may be held constant or expected to be "averagely randomized" in effect. Then:

Example: We have three operators who exchange between running two different paper machines. Is there a significant source of variation assignable to the operator, machine, or combination of a certain operator with a certain machine?

Prime variables	*Levels of variation*	=	*No.*
Machine tender	A.M. shift Swing shift P.M. shift		3
		×	
Paper machines	No. 1 No. 2		2
	Total tests without replication		6
		×	
Variation in basis weight and tonnage produced to be used as basis for data and computation. Data to be collected on 5 different days; with three tests run each day			5 × 3
	Total tests		90

EXPERIMENTAL PLOT

Shifts	A.M.		SWING		P.M.	
Machines	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
DAY 1	✓* ✓ ✓					
DAY 2	✓ ✓ ✓					
DAY 3	✓ ✓ ✓					
DAY 4	✓ ✓ ✓					
DAY 5	✓ ✓ ✓					

* Individual tests to be run, remainder of the chart would be similar.

Final Computation will show the degree of significance in variation assignable to:

Machine tenders, Paper machines } Primary variables
Tender × machine—Interaction
Residual: internal variability of the test; if too great there will be no, or part, significance in the above.

Note: Without replication the residual, internal variation, does not exist. If at all possible, at least duplicate tests need be run for the variance analysis.

You will see that in both or the above examples I have included the individual as a variable, along with the machine, process, or otherwise. It has been my experience that in any operation where personal judgment, adjustment, and manipulation is involved, the most likely source of the greatest portion of the variation is from personnel. When making machine or process capability studies in which you do not wish to

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include the operator as a variable, it is advisable to select one capable man and make all studies on his shift. You thus "standardize" his errors.

Time does not permit further exploration of this subject, but there are many other equally ingenious statistical aids. The monthly publication *Industrial Quality Control*, by the American Society for Quality Control, and the new periodical, *Technometrics*, published jointly by the ASQC and the American Statistical Association, keep one abreast of the new developments in this field.

As a closing subject, I should like to dwell briefly on "How does one get a statistical program going in a company?" It is very nice if the chairman of the board or the company's president can learn of its value from some friend (competitor usually in equal position). Then the company policy and budget for such a program are readily established. Such has often happened. But, in practice, it will probably end up where some young man with interest and energy will try and get going on his own. Hope he is not too young so as to have to learn the paper business and statistics at the same time, and not so old as to be of the school that relies more on art and experience regardless of what scientific facts and figures show. If you can pick three men, take the assistants in production, control, and research (or laboratory). Send them to one of the excellent short courses offered by many universities or the sections of ASQC. Encourage them to work along statistical lines. Once you get a start you do not have to worry; the fever is catching. Before long the production man will be passing on the basic concepts of normal variation to his group and you will wind up with control charts right at the paper machine itself. The competition for a machine tender to "stay-in-control" will bring out remarkable results. The control man will come to realize how much testing he must do to assure quality within certain average outgoing quality limits which assure catching a bad lot a certain percentage of the time, usually high, and likewise assure not rejecting a good lot as bad a certain per cent of the time, usually low. At the same time he will be glad to furnish production the needed information to keep in-control, making for better out-going quality. The research man will run designed experiments to gain the maximum amount of factual information in the minimum of time and effort. Production and quality of product will continue to improve in a systematic manner. All in all, your guesses will become more and more educated. Through it all the most pleasing and healthy picture of management will emerge—improvement in the profits. It will get bigger in terms of: less waste, better production in terms of quality and quantity, more rapid advancement in the art and science of the process or operation, better sales records through high quality of product, and, more satisfied customers.

I can make this firm prediction: If one of the paper companies represented in this meeting is now actively using statistics in all phases of its operations, for economic survival the remainder of you must join it. (I have been on many of your mill visits and seen little outward evidence of statistics at work.) If none of you is utilizing this science, you should—the horizons are phenomenal.

Presented at the meeting of the Gulf States Section of TAPPI held in New Orleans, La., May 15, 1959.

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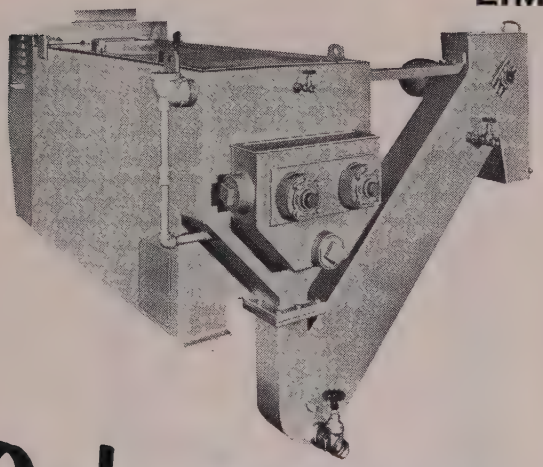

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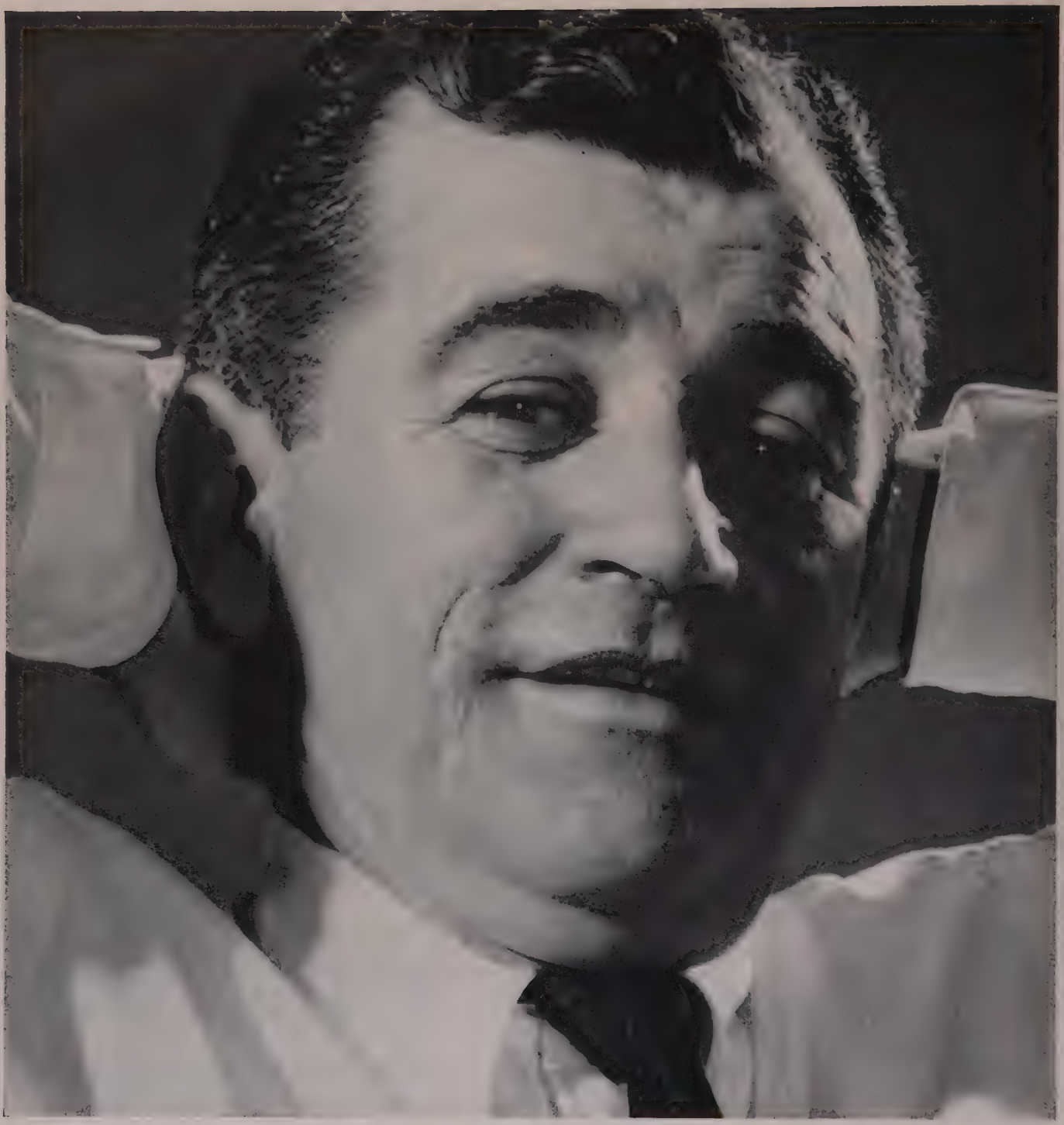

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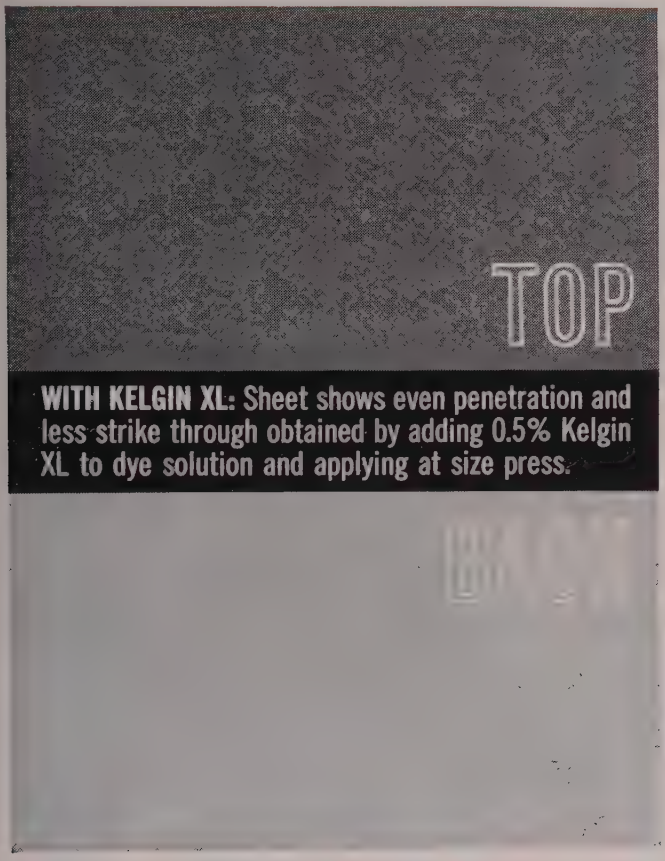
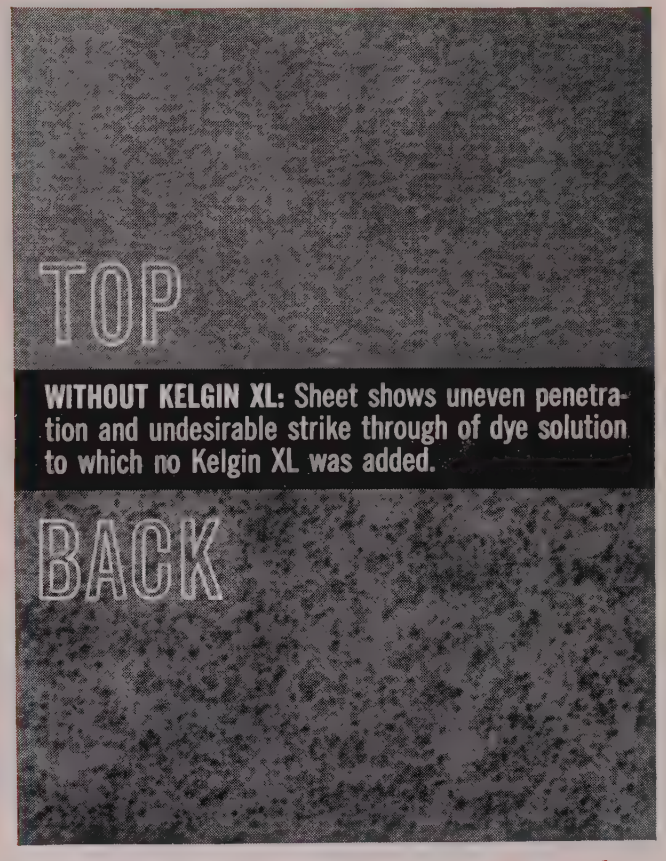


WITH KELGIN XL: Sheet shows even penetration and less strike through obtained by adding 0.5% Kelgin XL to dye solution and applying at size press.



WITHOUT KELGIN XL: Sheet shows uneven penetration and undesirable strike through of dye solution to which no Kelgin XL was added.

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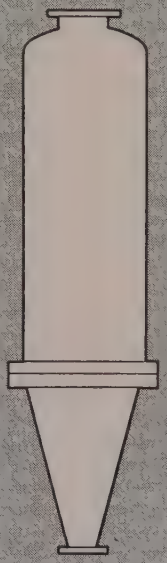
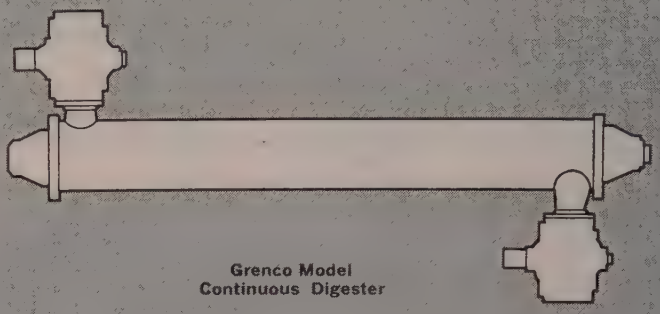


Rapid Cycle
Batch Cooker



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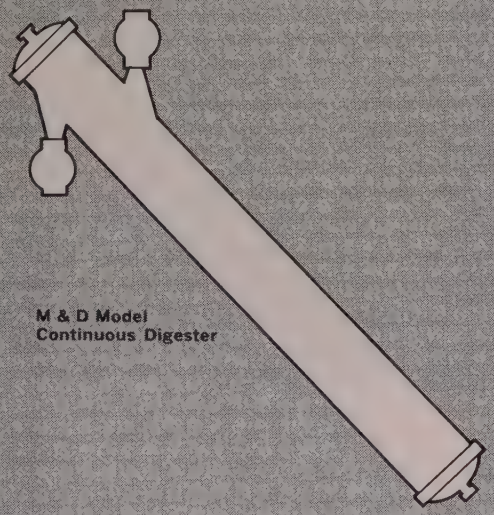
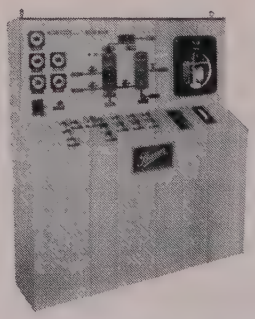
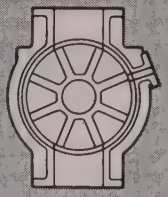


M & D Model
Continuous Digester

Electronic Controls (Optional)





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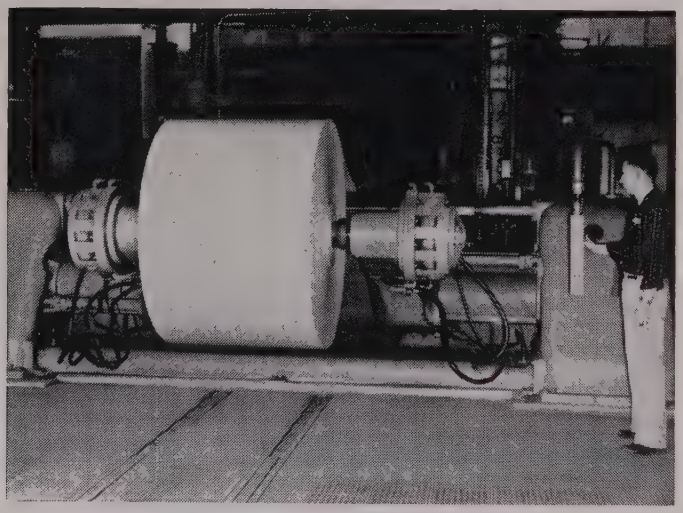

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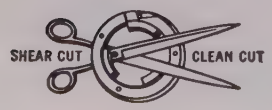

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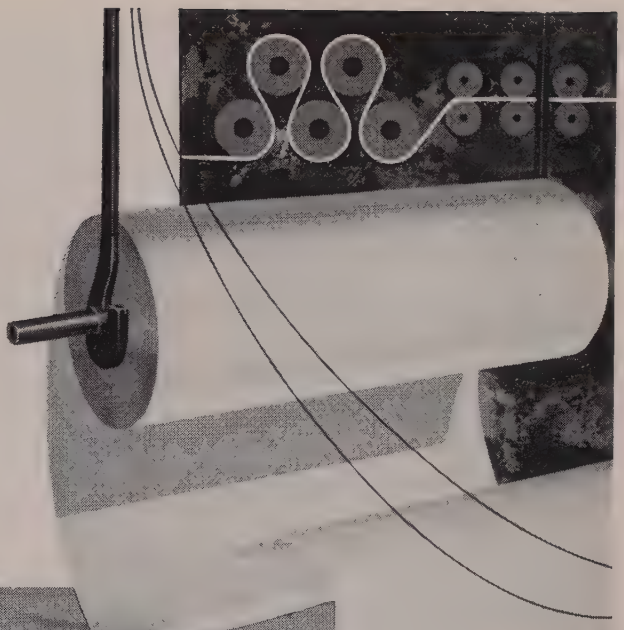
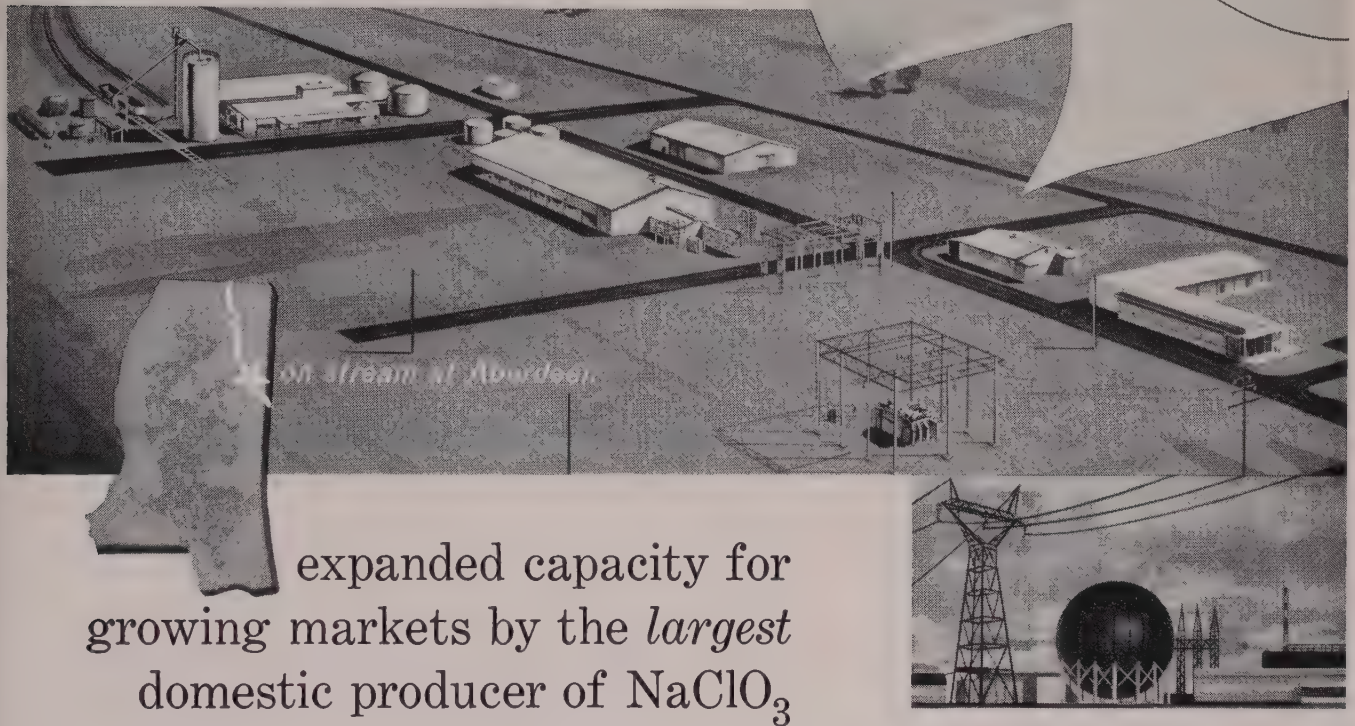
from Aberdeen, Mississippi





expanded capacity for growing markets by the *largest* domestic producer of $NaClO_3$

The big news in sodium chlorate is TRONA's new electrochemical plant, now on stream at Aberdeen, Mississippi. This latest AP&CC facility provides faster and better service to the South's growing pulp and paper production centers, as well as further assurance of dependable sodium chlorate supply for other important markets in such fields as agriculture, uranium ore processing and solid propellant fuels. Aberdeen's readily expandable, initial capacity of 15,000 tons per year, added to the $NaClO_3$ production capability of Trona's Henderson, Nevada, plant makes American Potash & Chemical Corporation the largest domestic supplier of sodium chlorate... capable of meeting *all demands* from expanding commercial and military users. *Further information on Trona's sodium chlorate service and production capabilities at Aberdeen is available from your nearest AP&CC branch office.*

TRONA

American Potash & Chemical Corporation

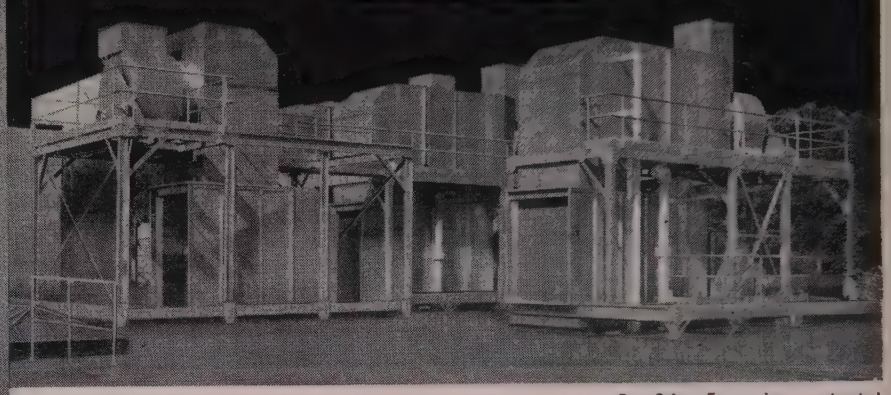
3000 WEST SIXTH STREET, LOS ANGELES 54, CALIFORNIA
99 PARK AVENUE, NEW YORK 16, NEW YORK
OFFICES: LOS ANGELES, NEW YORK, CHICAGO, SAN FRANCISCO, PORTLAND (ORE.), ATLANTA, COLUMBUS (O.), SHREVEPORT

Producers of: BORAX • POTASH • SODA ASH • SALT CAKE • LITHIUM • BROMINE • CHLORATES • PERCHLORATES • MANGANESE DIOXIDE
THORIUM • CERIUM • RARE EARTHS • *and other diversified chemicals for Industry and Agriculture*

ROSS
Air Systems

Engineered Atmospheres
for Better Processing

Now's the time for RESCUE WORK!



Ross-Briner Economizer constructed of aluminum permitting roof installation

MODERNIZATION WILL PAY OFF!

Ross-Hooper Hoods

Briner Economizers and Waste Heat Recovery

Coaters and Drying

Air Distribution for Comfort

Distribution Units for Uniformity of Drying

Automatic Controls

High Velocity Air Drying

With the accent on cost-reduction rather than greater plant capacity one good place to start is in replacing either inadequate, troublesome or even 'just getting by' equipment that is barely carrying its share of the load.

Let's call it 'rescue work'...and recently Ross Engineers have had a hand in several large scale rescue jobs.

In your mill, there are many units and systems where a Ross Specialist in the pulp and paper mill 'Engineered Atmospheres' could help in evaluating a rescue job. Call him in for a study. He will furnish you with a detailed report on each item studied with recommendations covering its replacement with modern units or systems so as to reduce your unit costs.

M-R MIDLAND-ROSS

THE MIDLAND-ROSS GROUP OF COMPLEMENTING SERVICES

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Ross Engineering of Canada Limited, Montreal
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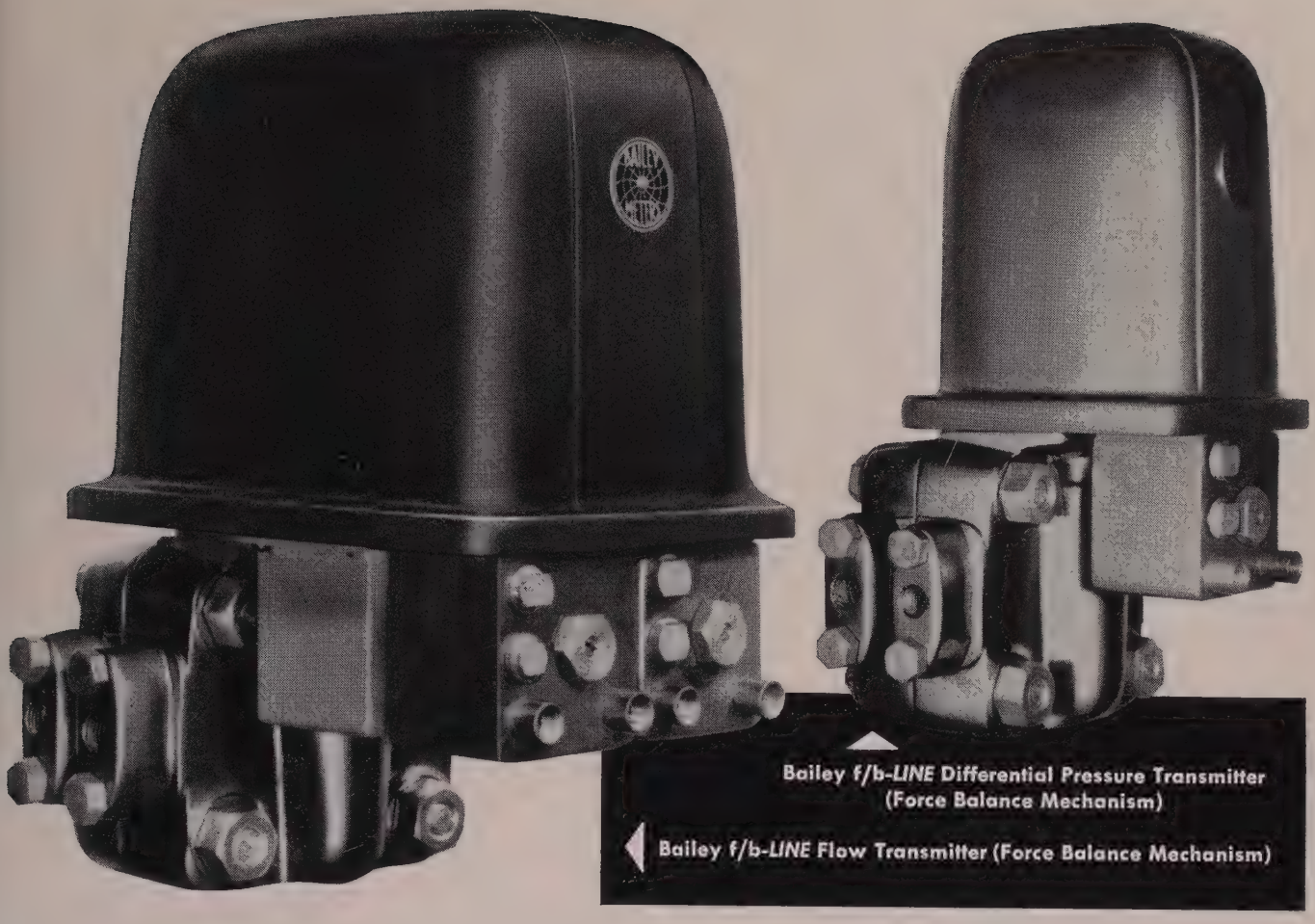
Bailey f/b-LINE Differential Pressure Transmitter (Force Balance Mechanism)
Bailey f/b-LINE Flow Transmitter (Force Balance Mechanism)

Two new Bailey *f/b-LINE* Transmitters

permit new accuracy in measuring flow and differential pressure

Pneumatically transmits rate of flow—or differential pressure—measurements to indicating, recording, and/or controlling equipment at remote stations. Transmitters consist of a diaphragm measuring mechanism and a force balance pneumatic transmitting unit.

APPLICATION

For steam, water, air, gases and other fluids producing differentials across primary elements from 0-2 in. H_2O to 0-2000 in. H_2O at maximum service pressure of 50, 1500, and 5000 psig.

FEATURES

Transmits a Signal Directly Proportional to Rate of Flow. Uses receiver with uniformly-graduated chart or scale. Eliminates need for external square-root extractors or characterizers.

10 to 1 Turndown. Differential range of each diaphragm measuring element may be changed by factor of 10 to 1; e.g., 0-20 in. H_2O diaphragm may also measure 0-2 in. H_2O.

Screwdriver Adjustments. Range and zero adjustments readily accessible. Range may be changed with screwdriver adjustment.

Overpressure Protection. Protects against full service pressure applied to either side of diaphragm.

Fast Response. No viscous dampers needed, so speed of response is very fast.

Corrosion Resistant. For maximum differentials between 20 and 2000″ H_2O, all parts in contact with process fluid may be stainless steel. No sealing fluids or sealing diaphragm required.

Good Stability. Reset type boosters give good stability with high gain.

Versatile Mounting. May be mounted on process piping, wall, or separate mounting pipe using same bracket.

For additional information, call your local Bailey District Office, or write direct.

P46-1

Pulp and paper division

BAILEY METER COMPANY

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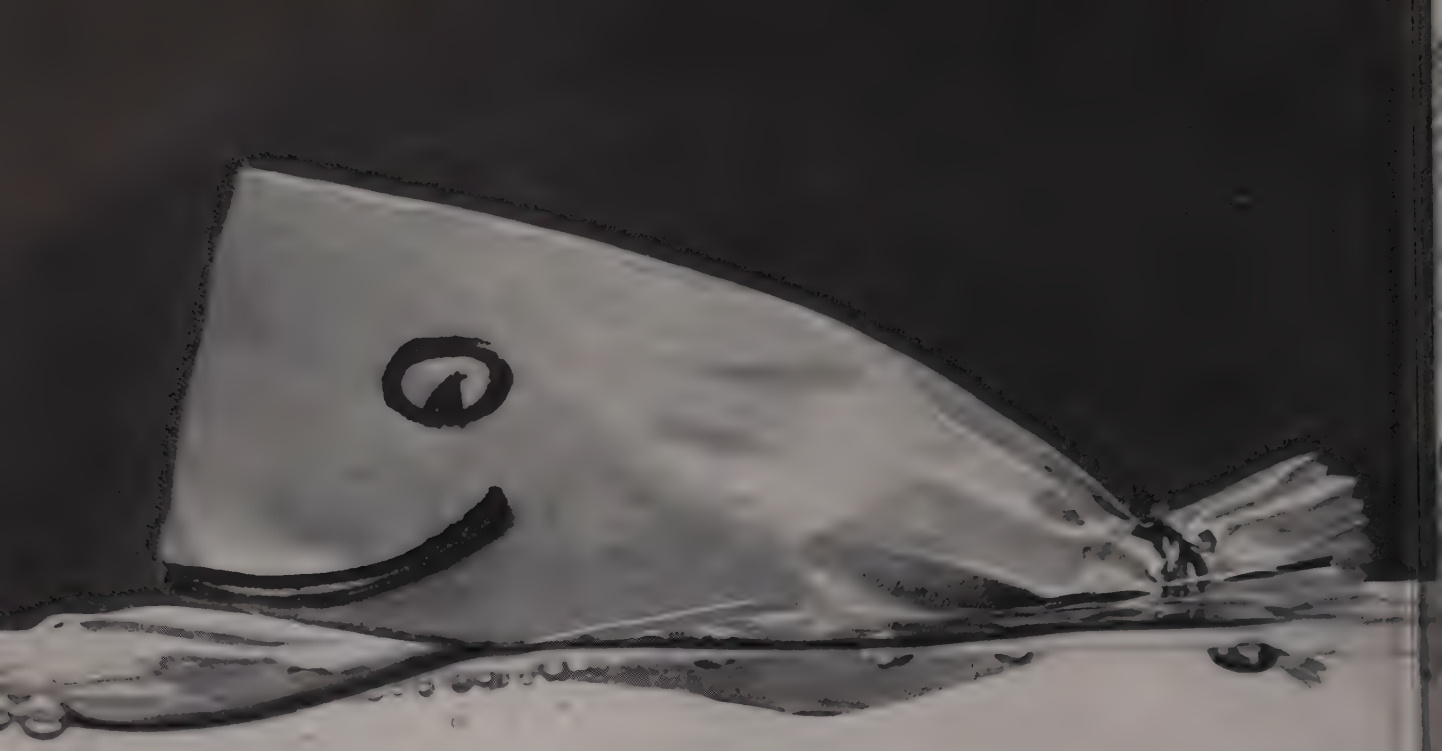
In Canada—Bailey Meter Company Limited, Montreal



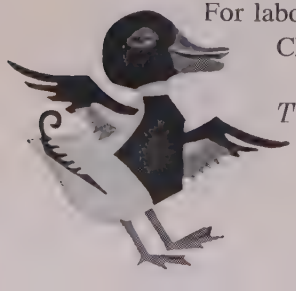
this paper was treated with

SCRIPTITE* 33

A melamine resin supplied as a finely divided dry powder, Scriptite 33 imparts high wet strength to many paper products. Count on Scriptite 33 to increase dry tensile strength and wet rub resistance . . . to improve dry Mullen, wax pick, internal size efficiency, and dry stiffness. Scriptite 33 produces papers with strong fold endurance. For laboratory samples of Scriptite 33 and technical bulletin, write Monsanto Chemical Company, Plastics Division, Room 1155 Springfield 2, Mass.

Monsanto

*SCRIPTITE: Reg. U.S [illegible]



The Monsanto line of paper resins also includes

SCRIPTITE 40 . . . *a urea type wet-strength resin.*

SCRIPTITE 50 . . . *for unsurpassed printability and improved surface characteristics on boxboard.*

SCRIPTITE 52 . . . *in combination with formaldehyde to give water resistance to folding boxboard and to jute liner.*

SCRIPTITE 54 . . . *for outstanding water resistance and both wet and dry rub resistance.*

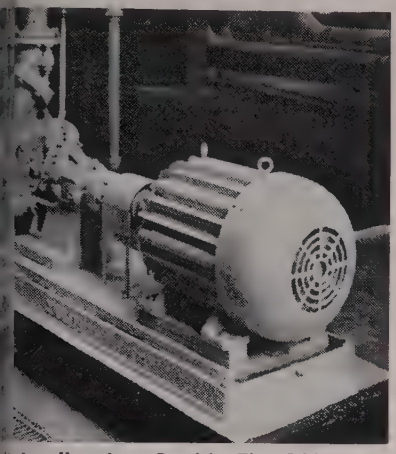
arathon Southern Corporation's all-new mill uses over 00 Goulds pumps to do a wide variety of pumping jobs—umping everything from mill water to liquors and stock.

Look over these Goulds installations at Marathon South-n's new facilities in Naheola, Ala. See the diverse services oulds pumps provide—at pumping rates that range from 5 to 15,000 GPM. Goulds offers a choice of many different ypes of pumps for every job, as well as a wide range of aterials of construction.

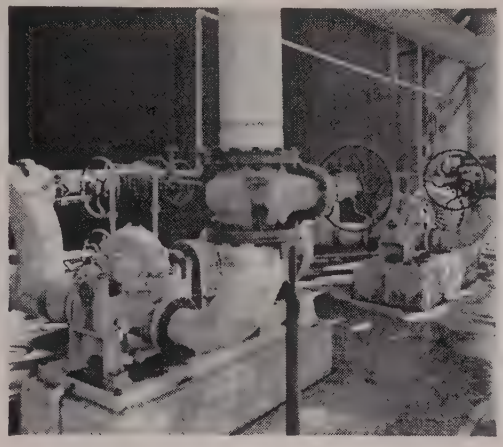
To select the right pump for *your* job—whether it be in igester plant, stock plant, bleach or paper mill—talk to a oulds representative. You can get in touch by writing to oulds Pumps, Inc., Dept. TA-89, Seneca Falls, N. Y.

GOULDS PUMPS

Mill water supply. Three Goulds Fig. 3450 pumps provide 10,000 GPM each, heads of 125 ft.

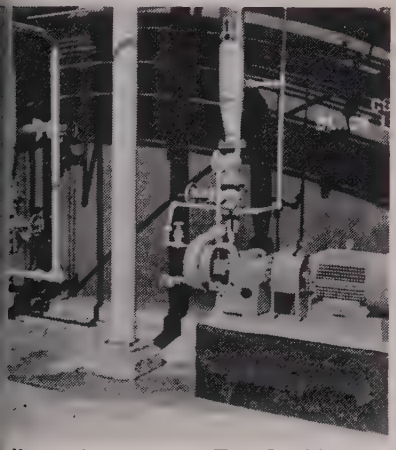


to digester. Goulds Fig. 3135 es black liquor and knots at , 500 GPM, head of 90 ft.

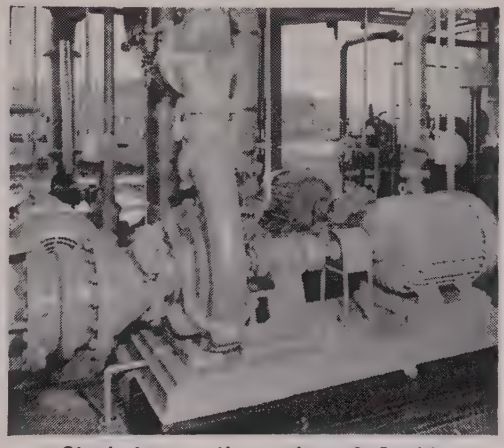


White liquor to measuring tank. Two Goulds Fig. 3405 pumps move white liquor at 1000 GPM each to a head of 100 ft. No. 316 SS construction.

Stock to stock-preparation room. A Goulds Fig. 3135 moves 4% stock at a rate of 1600 GPM, head of 70 ft.

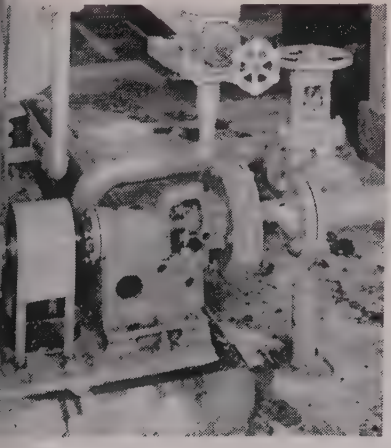


liquor to recovery. Two Goulds pumps handle black liquor at PM each to a head of 65 feet. 16 SS construction.

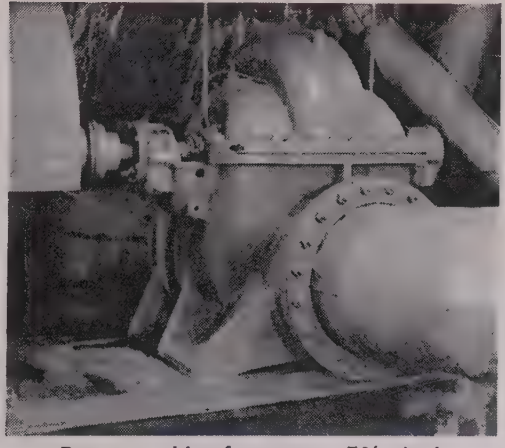


Stock to caustic washer. A Goulds 3135 moves 2½% kraft stock at 2400 GPM to a head of 68 feet.

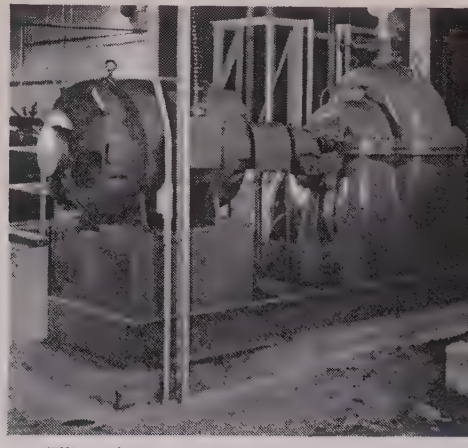
White water to chlorine washer. Goulds 3405 handles filtrate at a rate of 4500 GPM to a head of 80 ft. No. 317 SS construction.



size emulsion. A Goulds Fig. handles 4% rosin size emul-t 25 GPM to a head of 65 ft.



Paper machine fan pump. .5% stock moves at a rate of 15,000 GPM in this Goulds Fig. 3420. Head is 60 ft.



Filter back wash pump. This Fig. 3423 is handling water for filter back wash. 13,000 GPM. 60 ft. head.

One in a series of interviews with the men who are "Virginia"

"Bleaching groundwood pulp with hydrosulfites can be done easily—with minimum capital investment—for less than $6 per pulp ton, including chemicals and steam for heating"

Robert Barton, a "Virginia" technical representative

Simplicity of operation, low cost, high pulp brightness—these factors have attracted many groundwood pulp processors to the use of either sodium or zinc hydrosulfite as their principal bleach agent.

The advantages of hydrosulfite bleaching are discussed by Robert Barton, a technical representative of Virginia Smelting Company.

Q How does the cost of bleaching with hydrosulfite compare with the cost of oxidizing bleaches?

A Extremely well. The cost of using zinc or sodium hydro usually runs less than one-half that of the oxidizing bleaches, and with equally good results.

Q Just what is the brightness gain using hydro?

A That question has to be qualified somewhat, I think. You see there are factors that have to be considered in bleaching groundwood pulp with hydro —the *p*H of the stock, temperature, reaction time, iron content of the pulp and of the process water. But with reasonably good conditions, single-stage bleaching with hydro will result in about 10 or 12 brightness points gained.

Q Does installation of equipment present any problem?

A Not at all. Most manufacturers who have gone to the hydro bleaching process are well pleased with the simplicity of the installation. And at the low cost, I might add. Generally they can use existing chests and pumps in their plants —adding necessary piping. Not much more is needed.

Q Do the hydrosulfites offer any advantages to a manufacturer now using peroxide for his bleach?

A Very definitely. In our laboratories at "Virginia" we have helped develop the 2-stage bleach for groundwood pulp that gives an absolute maximum brightness—at a cost that cannot be touched by any other method.

Q How does this 2-stage bleaching work?

A Well, for brightness gains up to 12 points, of course, the single-stage hydrosulfite bleach is the most economical. But for gains from 12 to 20 points, we recommend a 2-stage bleach. The first stage is a peroxide bleach. We follow that with a sulfur dioxide treatment to remove any residual peroxide in the slurry. This is followed by a hydro bleach. We will be happy to furnish all the data to anyone interested in this process.

Q Does "Virginia" offer technical assistance to any manufacturer interested in either the single-stage or 2-stage bleach process?

A A great deal. Our experience in this field is long and extensive, and available to anyone interested. For preliminary bleaching studies, we maintain a complete pulp laboratory at our plant. To solve certain types of problems, we obtain pulp samples, make laboratory bleaches, study the brightness gains along with any contributory factors, and make a complete report to the manufacturer. Along with the report go our recommendations—and of course our laboratory men are quite impartial in their findings. If the manufacturer has a process involving problems that make hydro impractical for any reason, we will tell him so quite frankly. But this occurs very infrequently. We welcome inquiries from any manufacturer interested in exploring the possibilities of hydrosulfites in pulp bleaching.

• • •

FOR MORE DATA ON HYDROSULFITES

write to us on your company letterhead describing your present bleaching process, giving full details wherever necessary. We will send you pertinent technical bulletins from the extensive "Virginia" library of literature on pulp bleaching. If you prefer, we will have a "Virginia" man call on you.

Industrial Division
VIRGINIA SMELTING COMPANY
Dept. 315 West Norfolk, Va.

VIRGINIA® Chemicals

Field Offices: New York • Boston • Memphis • Chicago
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DOW | COATINGS

DOW LATEX "BEEFS-UP" BOXBOARD COATINGS!

Newsboard maker gets better binder at no extra cost

A switch from casein to Dow Latex as a coating binder for boxboard has resulted in better quality board and easier processing for a large midwestern manufacturer of clay-coated board.

Here's how: By substituting Dow Latex for casein in the binder formulation, they were able to obtain a pigmented clay coating with a lower viscosity, but containing a higher percentage of solid materials.

Result: Now, the new high-solids formulation with Dow Latex gives them a higher quality board with a heavier coating and better coverage—and as a result—better overall printability! The higher percentage of latex present in the coating means easier finishing on the calender — and a smoother, glossier board.

Many leading paper and board manufacturers are discovering the advantages of Dow Latex. Chances are a change to Dow Latex in the coating will make your boxboard behave better—in your production processes, and in your customer's end use. Why not contact the nearest Dow sales office, or THE DOW CHEMICAL COMPANY, Dept. 2321FC8, Midland, Michigan, for complete technical information.

THE DOW CHEMICAL COMPANY · MIDLAND, MICHIGAN

CONTROLLED ABSORBENCY FOR LAMINATE DECORATIVE SHEETS WITH SOLKA® PULP

Manufacturers of decorative sheets for high pressure laminates find Solka Pulp ideal for the purpose. Paper made from these specially blended Solka fibres has an excellent printing surface and high dimensional stability. And of utmost importance, this paper has a uniform absorbency rate and capacity for saturants.

In addition to the standard grades, Solka Pulps can be tailor-made to give specific properties to papers designed for particular applications.

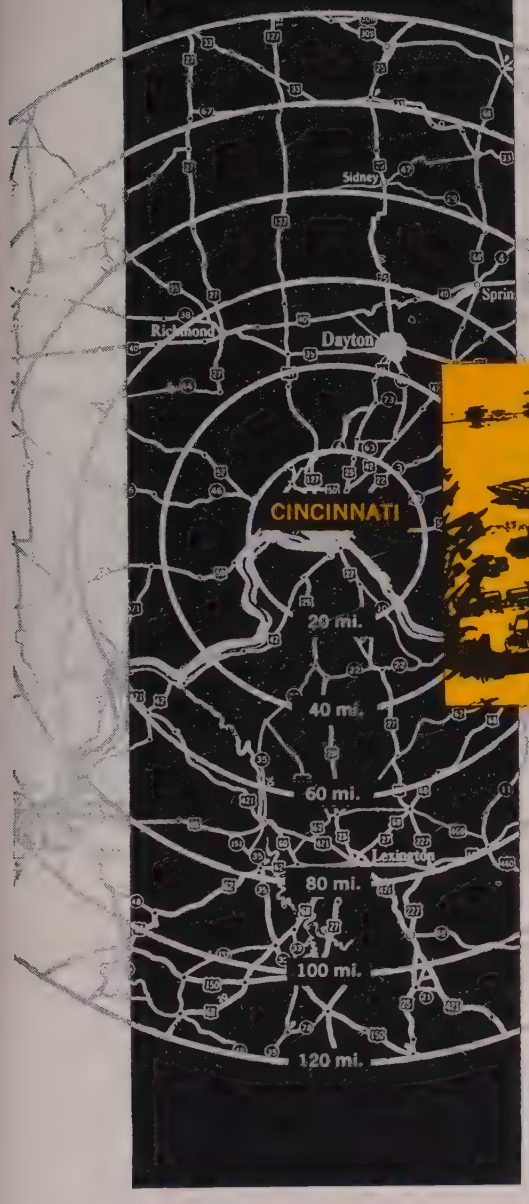
Brown Company's sixty years of pulp making experience is backed by top-flight research and technical personnel. This, plus modern manufacturing facilities, can help you in solving your problems. Write our Boston office today. Address Department PD-8.

Another Quality Product of BROWN COMPANY

150 Causeway Street, Boston 14, Mass.
Mills: Berlin and Gorham, New Hampshire

NOW.... PROMPT MOLTEN SULPHUR DELIVERIES

Radiating out from Cincinnati



This is the first of the TGS Terminal Molten Sulphur Truck and Rail Distribution Stations being set up to serve industrial areas of the country. Regular large tonnage barge shipments of Molten Sulphur from our mines in the Gulf area are keeping this Cincinnati Terminal well-stocked to meet the growing demand for Molten Sulphur in the Ohio River area.

Additional Molten as well as Solid Sulphur terminals are being considered for other parts of the country.

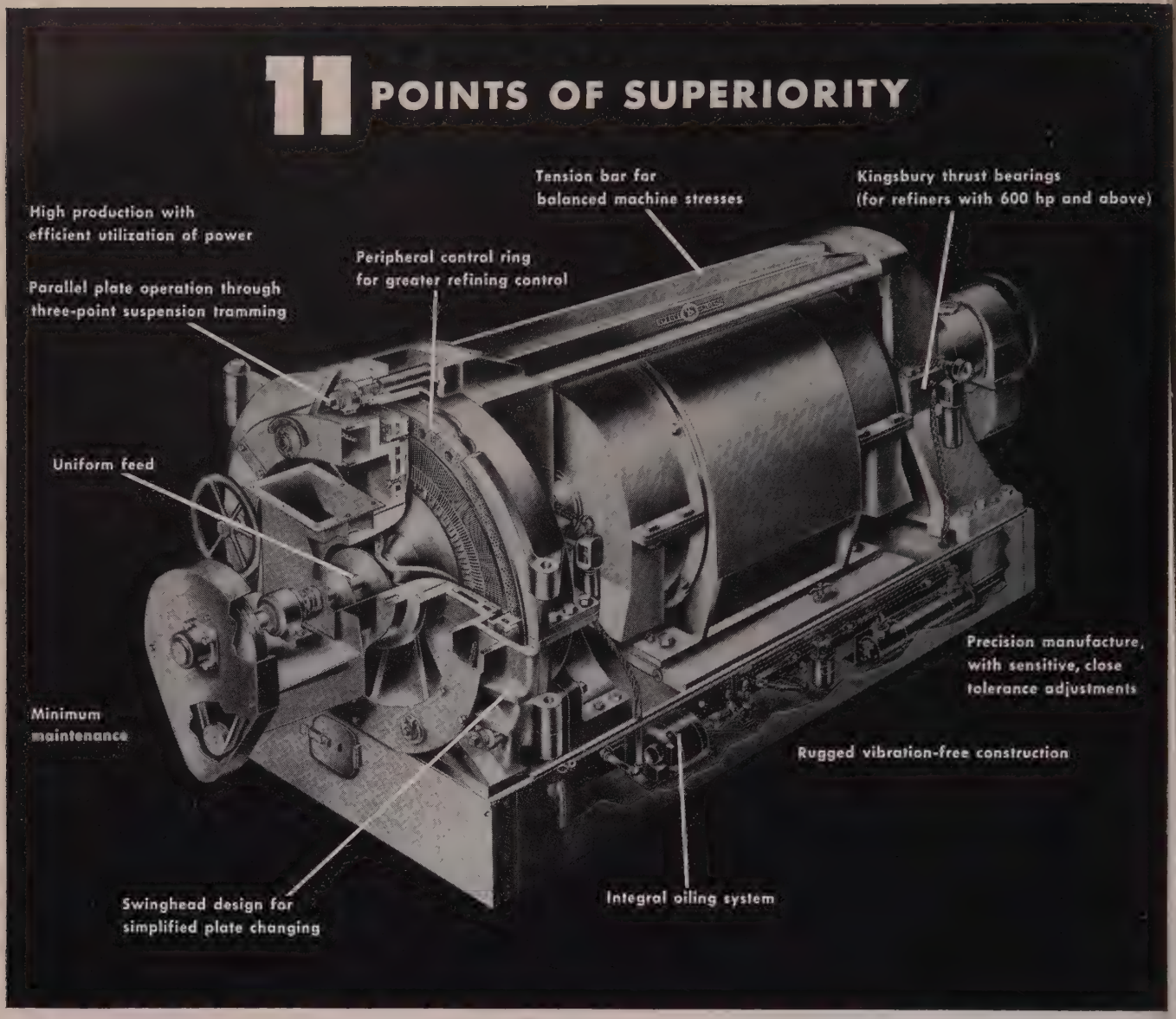
TEXAS GULF SULPHUR COMPANY

75 East 45th St., New York 17, N. Y. / 811 Rusk Ave., Houston 2, Texas

Sulphur Producing Units: Newgulf, Texas • Spindletop Dome, Texas • Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming •

Molten Sulphur in tank *cars* can be delivered to any point in the States or Canada from our nearest mine or recovery plant. Barge deliveries of Molten Sulphur are available on all navigable inland waters. Solid Sulphur, as for many years, is deliverable all over the world. Large inventories at our mines assure industry it will get its supplies when needed.

11 POINTS OF SUPERIORITY


Tension bar for balanced machine stresses
Kingsbury thrust bearings (for refiners with 600 hp and above)
High production with efficient utilization of power
Peripheral control ring for greater refining control
Parallel plate operation through three-point suspension tramming
Uniform feed
Precision manufacture, with sensitive, close tolerance adjustments
Minimum maintenance
Rugged vibration-free construction
Swinghead design for simplified plate changing
Integral oiling system

THE WORLD-FAMOUS 36-2 "SPROUT"

single disc precision pulp refiner

The 36-2 Sprout refiner is the most efficient disc refiner in quantity of output and in quality of refined pulp per horsepower input. It is preferred throughout the industry for every pulping application where rubbing and brushing action, without cutting, is required. Sprout-Waldron units lead the field in the refining of semichemical pulp, cold caustic pulp, screen rejects, wastepaper stock; brown stock and hot stock refining of high yield kraft pulp; refining of bagasse, flax and straw pulping; as well as preparation of insulation and hardboard fiber. For the latest details on the 36-2 Sprout, request Bulletin 96-B.

SW

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA, U. S. A.

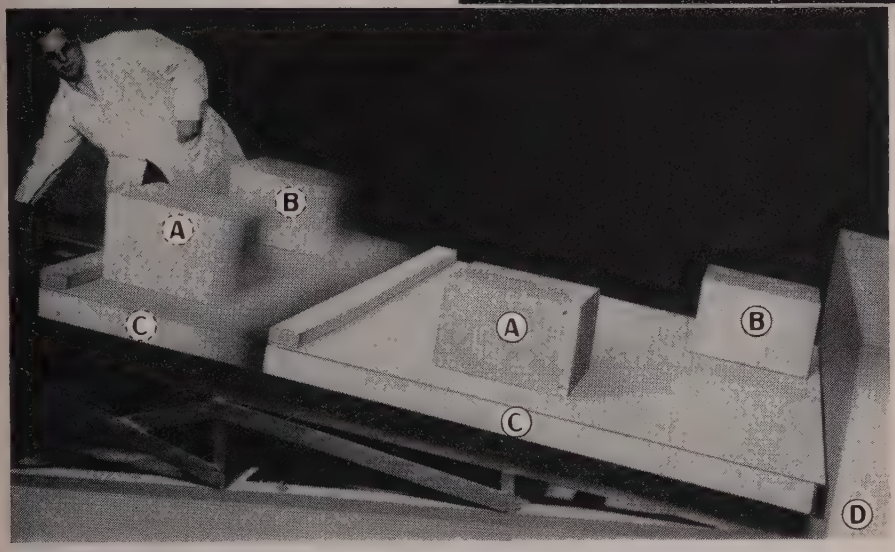
SINCE 1866 REFINERS • DIGESTERS • CONVEYORS • FEEDERS • SCREENS • MIXERS • DRAINERS • FIBER PRESSES • STOCK PROPORTIONERS

E/200

DU PONT
REG. U. S. PAT. OFF
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

chemical briefs

FOR THE PAPER INDUSTRY



SLIP RESISTANCE of boxboard containers is measured by Conbur Impact Tester which simulates impacts received by packages during shipping. Carton treated with "Ludox" (A) is placed on treated kraft paper, which covers one half the surface of the sliding inclined plane (C). Untreated carton (B) is placed on untreated kraft paper. The inclined plane is released, striking stop (D) with an impact equivalent to a dead stop at 6 mph. Repeated tests show treated cartons slide only ⅓ as far as untreated cartons.

DU PONT ENGINEERING TESTS PROVE . . .

Anti-slip coatings of Du Pont LUDOX® reduce slippage of corrugated cartons by 67%

Losses due to damage in handling and shipping greatly reduced

Invisible coatings of Du Pont "Ludox" colloidal silica on corrugated cartons can mean the difference between safe shipment and costly damage. Using the Conbur Impact Tester (above) the Du Pont Engineering Test Center simulated impacts received by packaged products during shipping. Result: Cartons treated with "Ludox" slip 60 to 70% less than untreated containers!

This fact is important since Du Pont experience shows that 75% of all damage to one-trip fiberboard cartons results from impacts received during coupling and normal starts and stops in rail shipment.

What this means to package users

There's less damage to packaged products because of (1) reduced movement of treated packages in rail and truck shipment, and (2) greater stability of carton loads during in-plant handling. Treated packages stack solidly with less danger to personnel. And the expense of repackaging due to damage is reduced.

Coatings of "Ludox" can be applied to finished packages or to paper products by mills or converters. Treated packages resist soiling, permit sharper printing . . . increasing customer appeal of finished packages.

Names of suppliers of treated packages and more information about "Ludox" are available on request. Just fill out and mail coupon below.

New Du Pont program offers tailor-made adhesives for paper laminates

When special adhesives are needed for strong paper-to-paper bonds, or where equipment calls for particular formulations . . . chances are Du Pont can tailor-make a Weatherproof Adhesive to fill the bill.

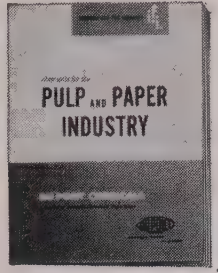
Manufacturers of laminated paper products are invited to take advantage of special Du Pont facilities which are available for solving adhesive problems and for compounding adhesives suited to difficult product requirements. The coupon will bring further information.

CHEMICALS BASIC TO THE PAPER INDUSTRY

In addition to a group of specialty chemicals that offer unique benefits to end products, the Du Pont Industrial and Biochemicals Dept. also supplies the following basic chemicals to the pulp and paper industry:

Aluminum Chloride Solution	Reagent Acids and Ammonia
Aluminum Sulfate	Salt Cake
Ammonium Sulfamate	Sodium Carbonate
Aqua Ammonia	Sodium Phosphate — DI
Caustic Soda	Sodium Tripolyphosphate
Copper Sulfate	Sodium Pyrophosphate
Diatomaceous Earth	Sodium Silicate
"Lignasan" X Fungicide	Sodium Sulfite
Mineral Adhesive Solution	Sodium Thiosulfate
	Sulfamic Acid
	Zinc Chloride

MAIL COUPON for your copy of "Chemicals for the Pulp and Paper Industry," which describes the benefits made possible by Du Pont Chemicals. Perhaps you'll find new ways to improve product quality, build sales appeal. E. I. du Pont de Nemours & Co. (Inc.), Industrial and Biochemicals Dept., Room N-2543, Wilmington 98, Delaware.



E. I. du Pont de Nemours & Co. (Inc.)
Industrial and Biochemicals Department, Rm. N-2543T
Wilmington 98, Delaware

Please send me a copy of "Chemicals for the Pulp and Paper Industry" and more information about: ☐ Anti-slip coatings of "Ludox"; ☐ Tailor-made Weatherproof Adhesives.

Name _____ *Title* _____

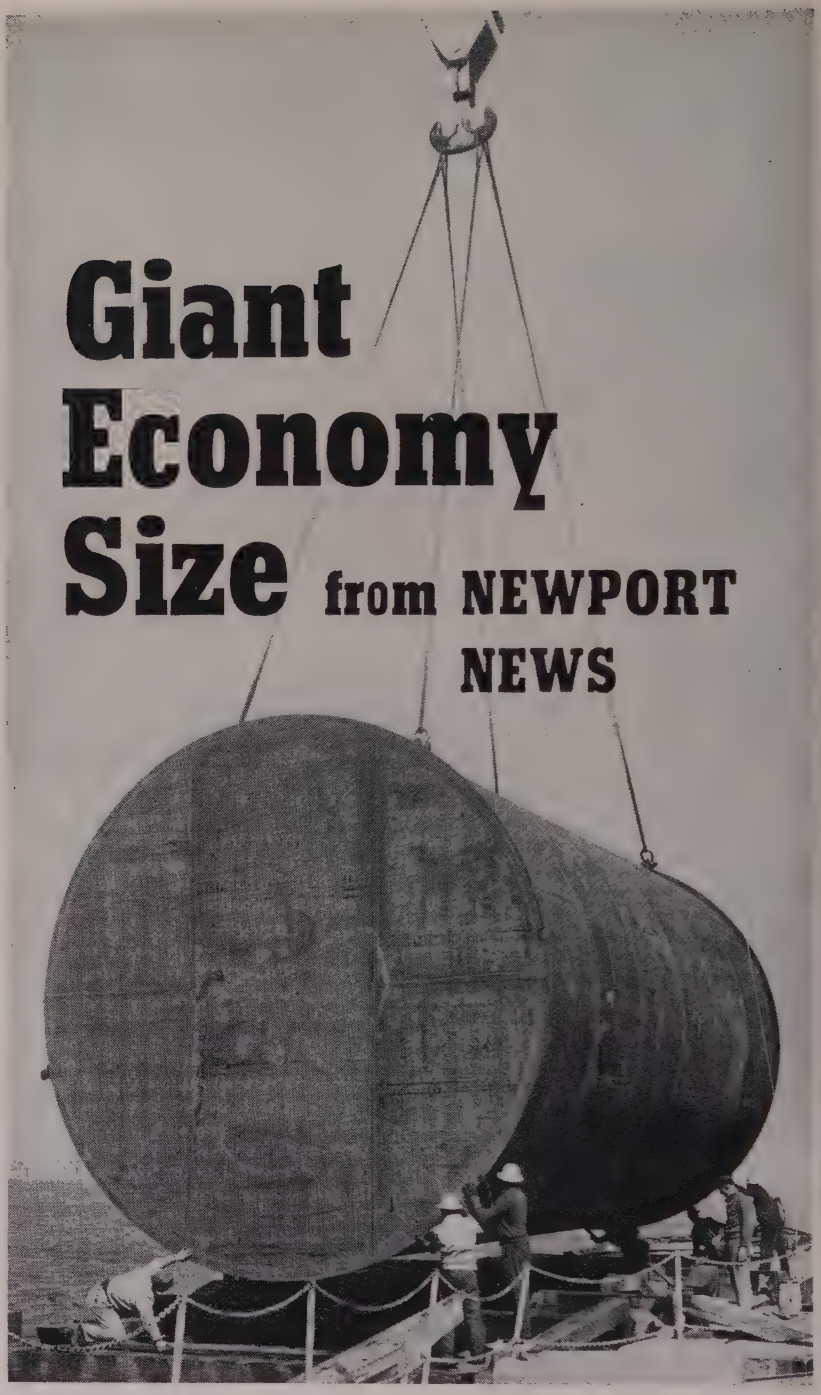
Firm _____

Address _____

City _____ *State* _____

Why a Southern paper mill ordered the...

Giant Economy Size from NEWPORT NEWS



Papermakers usually encounter some perplexing problems when pressure vessels, digesters, tanks or similar large size units are involved.

For instance, a southern paper mill required ten lime storage tanks like the one pictured here. The size, 20 feet in diameter by 40 feet in length, obviously prohibited one-piece delivery by rail.

However, the mill found a way to eliminate field assembly problems and avoid needless labor costs, as well as to save valuable erection time . . . by handing the job to Newport News.

Specialists in metal fabrication, Newport News produced these tanks in the shop, then loaded them on barges for direct shipment, fully assembled, ready for immediate installation upon arrival.

This illustrates how deep water shipping, along with sixty-seven years' experience in building just about any kind of vessel you could name, has enabled Newport News to provide money-saving answers for scores of papermakers.

Papermaking equipment built by Newport News has set outstanding performance records in leading mills at home and abroad. So whether you use *rolls or log barkers . . . head boxes or pressure vessels . . . digesters, tanks or special equipment . . .* let us bid on your needs. Learn how Newport News can help you . . . our illustrated booklet *"Facilities and Products"* is yours for the asking. Write for your copy today.

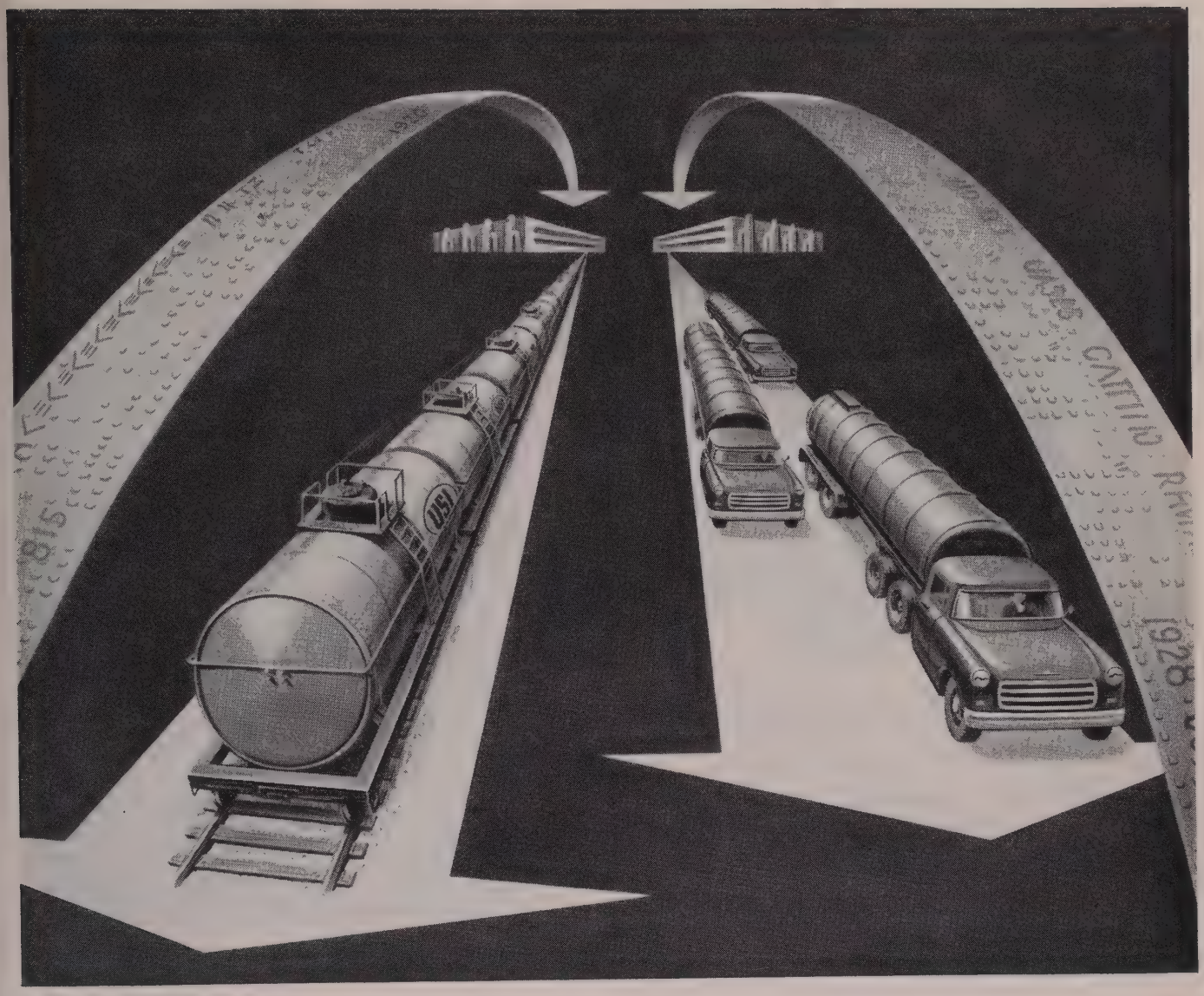
Nine more to go. You're looking at one of ten lime storage tanks being loaded on a barge for direct shipment from Newport News' plant. Complete assembly of these units in the shop not only saves labor and money but expedites installation upon arrival at the paper mill.

Newport News

Shipbuilding and Dry Dock Company

Newport News, Virginia

Engineers . . . Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.



AUTOMATION SPEEDS U.S.I. CHLORINE AND CAUSTIC SODA

. . . from Huntsville, Alabama

To U.S.I., customers' orders are high priority communications. That's why our offices and plants all over the country are linked in a 7,000-mile private wire network of teletypes and data processing equipment.

As one of U.S.I.'s customers for chlorine or caustic soda, here is the way this automated order handling system would insure quick delivery of *your* shipment. When your order is placed with the U.S.I. sales office in your area, it is transmitted by coded tape direct to Huntsville, Ala. Here automatic machines use the tape to produce shipping papers, invoice and such records as are needed for internal use. The system cuts as much as four days from the time that might be required to process your order by ordinary methods.

Ample capacity at U.S.I.'s two Huntsville plants is further assurance of expedited service.

Liquid chlorine is shipped from Huntsville in tank cars, commercial grade 50% liquid caustic soda in tank cars, tank trucks and barges. Other U.S.I. plants supply ammonia, polyethylene and sodium peroxide. Make U.S.I. *your* supplier of these paper chemicals. Our products and ability to serve you are discussed in the booklet "National Distillers and Chemical Corporation Expands in the Chemical Industry". We'll be happy to send you a copy.

U.S. Industrial Chemicals Co.
99 Park Avenue, New York 16, N. Y.
We'd like to know more about U.S.I.

- ☐ Send booklet "National Distillers Expands in the Chemical Industry"
- ☐ Send information on your Automated Order Handling System
- ☐ Have a salesman call for an appointment to discuss chlorine or caustic soda
- ☐ Put me on your mailing list

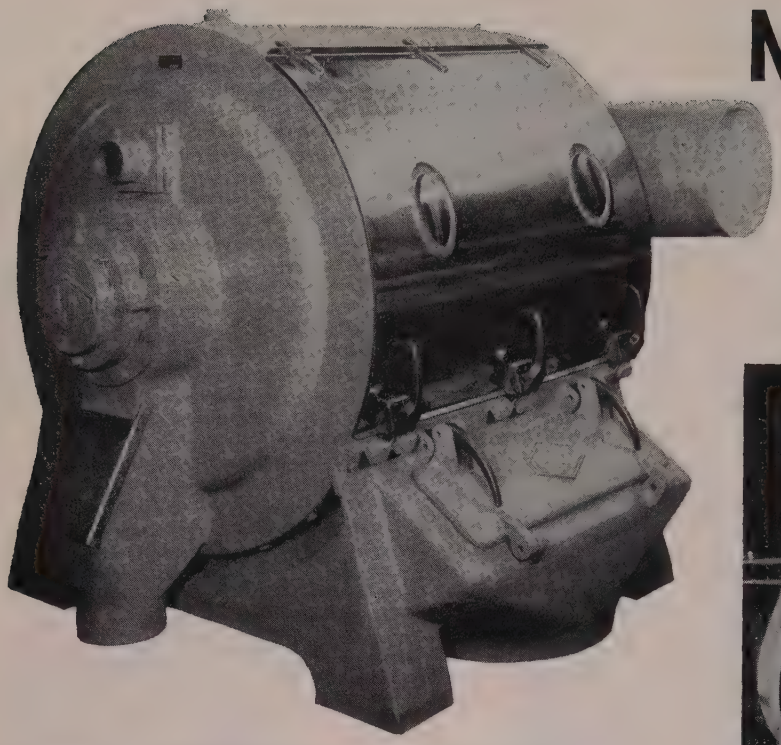
Name_____ Title_____

Company_____

Address_____

City and State_____

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities



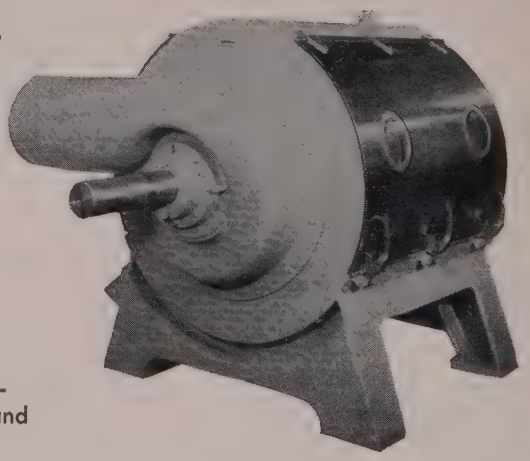
NEW ADVANCES IN LOW COST QUALITY PULP SCREENING

IMPCO CENTRIFUGAL SCREENS FOR:

Washed Stock Screening
Hot Stock Screening
Sealed Black Liquor Knotting
Fibre Length Classification
Paper Stock Cleaning

The new Impco Centrifugal Pulp Screen is the latest example of the progress made toward the ultimate in low cost quality screening. This screen incorporates many improved principles and features such as:

— a stock inlet allowing direct top, bottom, front or rear infeeding which simplifies installation piping;
— a tangential inlet which changes flow direction from linear to rotating, yet retains velocity head;
— a special stator which provides uniform internal distribution of pulp;
— a patented high-efficiency rotor which increases capacity without additional horsepower;*
— a bottom accepted stock outlet permitting all sub-floor piping;
— a full length quick-opening door for routine accepted stock sampling;
— an accessible rejects outlet for tailings inspection or sampling.



These features are resulting in peak capacities and high discharge consistencies at lowest horsepowers. Reject richness is readily controlled. Engineered simplicity is characteristic of the entire line of Impco Centrifugal Screens which require very little operating attention and mechanical maintenance.

* U. S. Patent No. 2,845,848.

IMPROVED MACHINERY INC.

NASHUA, NEW HAMPSHIRE

IMPCO®

In Canada, Sherbrooke Machineries Ltd., Sherbrooke, Quebec

SIBAKIS

is the abbreviation for the American Management Association's bright, new slogan *See It Big and Keep It Simple.* It is also the most appropriate word for describing Huyck's viewpoint toward synthetic-content felts.

Huyck sees it big by (1) laboratory testing every man-made fiber presently available or in the development stage . . . and (2) thoroughly field testing those that show the greatest promise of improved felt performance — so that only the best remain.

Huyck keeps it simple by using *only* those fibers that give our felts superior operating properties.

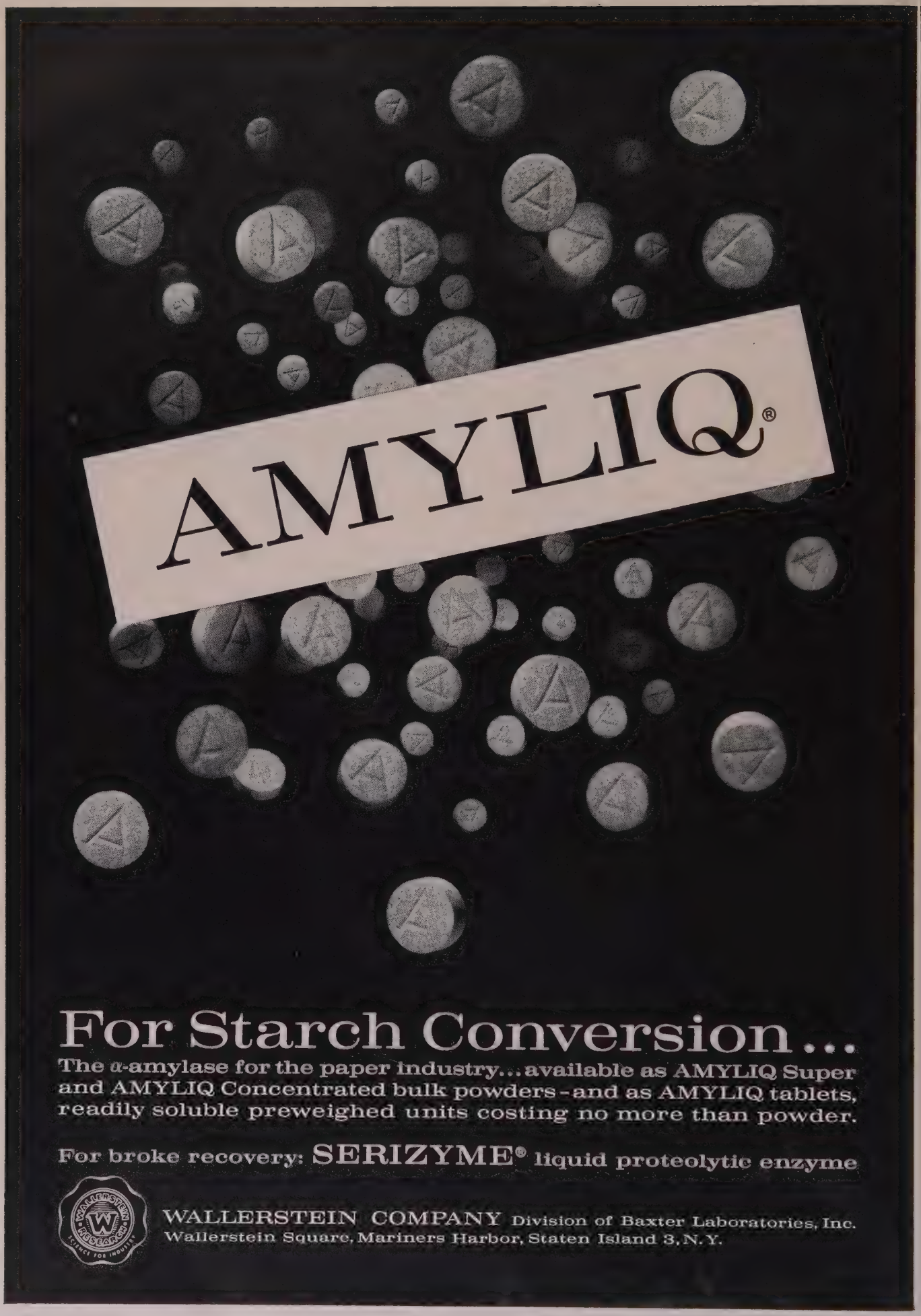
Your Huyck Field Service Engineer wants to work with you in analyzing your specific machine requirements. Let him help determine the advantages you can gain by employing synthetic-content felts.

HUYCK FELTS

Huyck Felt Co.,
Rensselaer, N. Y.;
Aliceville, Ala.;
Division of F. C. Huyck & Sons
In Canada: Kenwood Mills Ltd.,
Arnprior, Ontario.

NEW
HUYCK FELTS
★ INDUSTRIAL FABRICS

FIRST IN QUALITY • FIRST IN SERVICE SINCE 1870



For Starch Conversion...

The α-amylase for the paper industry... available as AMYLIQ Super and AMYLIQ Concentrated bulk powders - and as AMYLIQ tablets, readily soluble preweighed units costing no more than powder.

For broke recovery: SERIZYME® liquid proteolytic enzyme

WALLERSTEIN COMPANY Division of Baxter Laboratories, Inc.
Wallerstein Square, Mariners Harbor, Staten Island 3, N.Y.

EC&M *Fuseless* AIR-BREAK STARTER GIVES Certified 100/150 MVA FAULT PROTECTION

NO SINGLE PHASING FROM BLOWN FUSES!

NO COSTLY REPLACEMENT FUSES TO STOCK!

- ✓ Gang-operated Disconnect Switches Grounded for Safety in Open Position. Mechanically Interlocked with Contactor . . . Never Open Under Load
- ✓ No Fuses. Bus Bars Throughout
- ✓ 3-way Door Interlock. On, Off and Open—with Positive Interlocking between Door, Disconnect and Contactor for Maximum Personnel Protection
- ✓ Heavy-duty DC Operating Magnet. No Chatter—No Hum

FRONT ACCESSIBLE WITHOUT ROLL-OUT!

Phase barrier and arc-chutes slide out. All starter parts exposed and accessible for easy inspection and maintenance

Get the complete story on certified fuseless fault protection for high-voltage motor drives. Write for Bulletin 8130A

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

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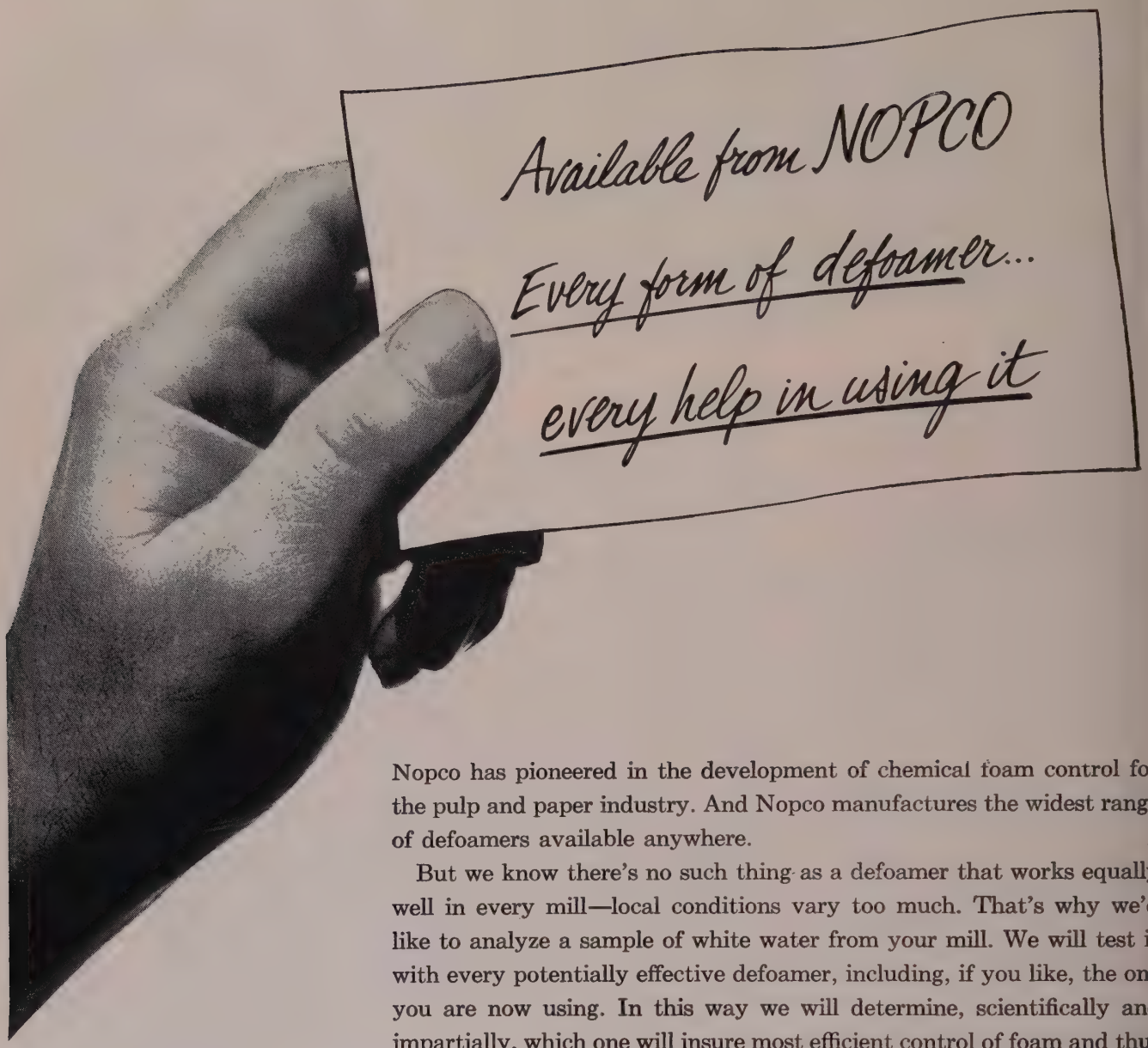


Nopco has pioneered in the development of chemical foam control for the pulp and paper industry. And Nopco manufactures the widest range of defoamers available anywhere.

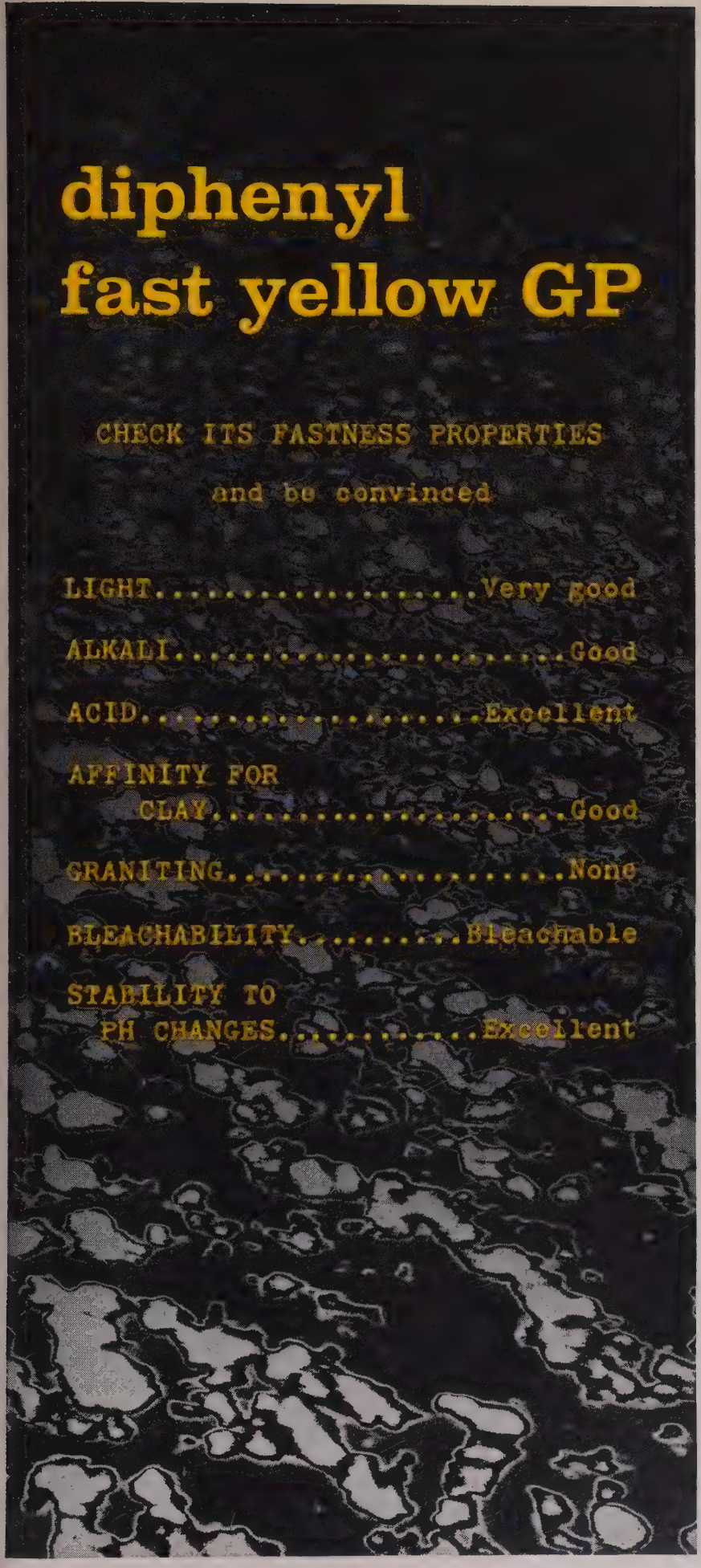
But we know there's no such thing as a defoamer that works equally well in every mill—local conditions vary too much. That's why we'd like to analyze a sample of white water from your mill. We will test it with every potentially effective defoamer, including, if you like, the one you are now using. In this way we will determine, scientifically and impartially, which one will insure most efficient control of foam and thus yield more even fiber distribution and improved sheet formation in your mill.

Remember, you can't be sure you've attained maximum defoaming efficiency at the lowest cost per ton until you've given Nopco a chance to prescribe. Call or write today.

NOPCO®

NOPCO CHEMICAL COMPANY 60 PARK PLACE, NEWARK, N.J.

Plants: Harrison, N.J. • Richmond, Calif. • Cedartown, Ga. • London, Canada



Geigy

diphenyl fast yellow GP

"A Product of GEIGY Research"

It will pay you to investigate this low cost direct yellow for buff, ivory and goldenrod printing papers. Also suggested for board, tissue and kraft specialties. GEIGY'S technical staff will be glad to assist you in the adoption of this suggestion.

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Division of Geigy Chemical Corporation
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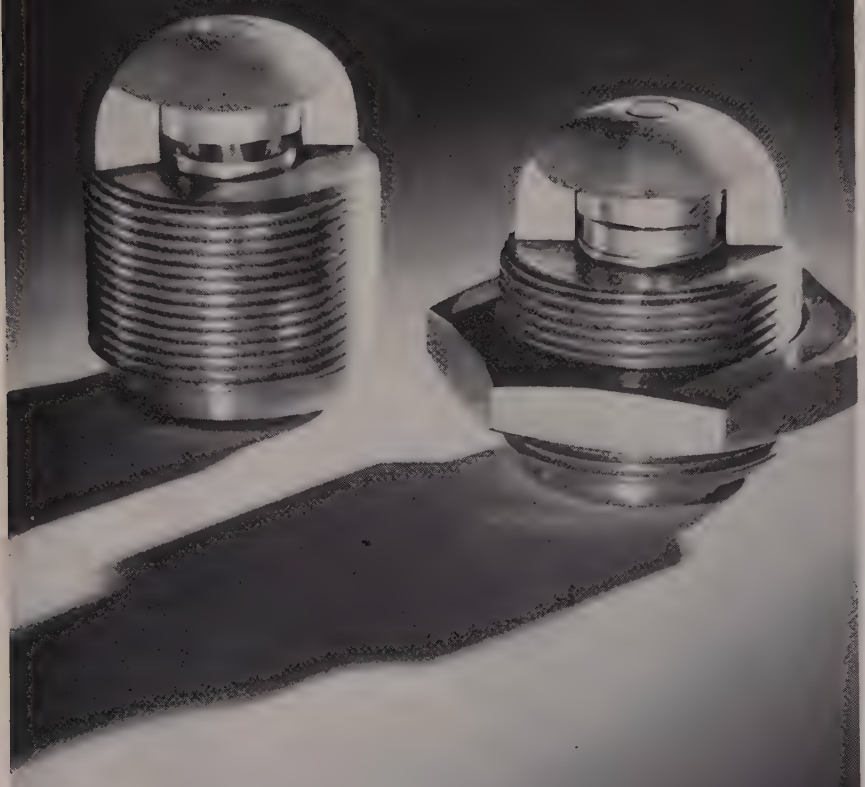
Conserve water with Lodding Self Cleaning Showers



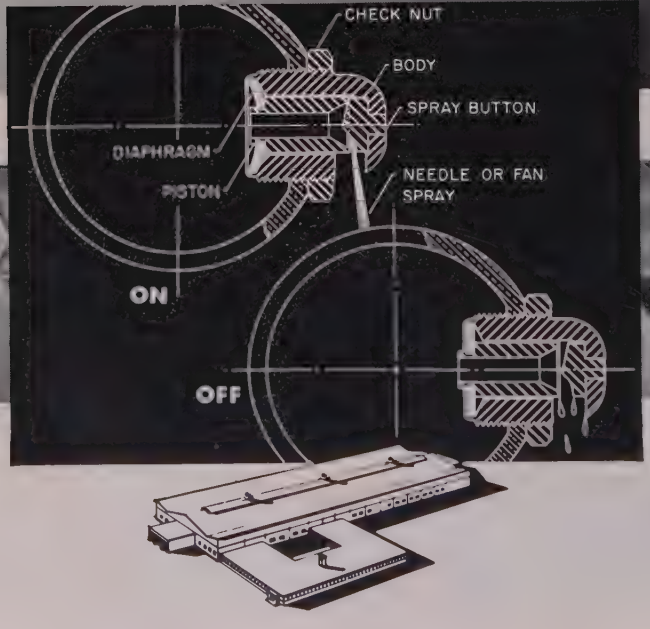
In mill after mill Lodding Showers are conserving water — cutting operating costs — performing effectively.

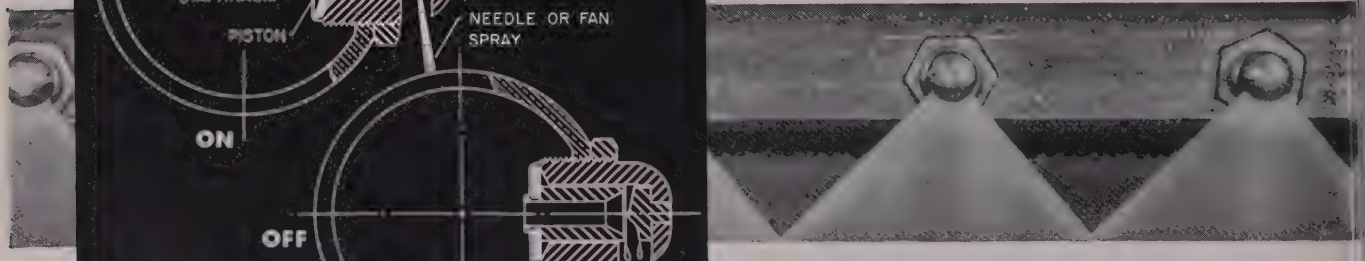
In showers it's the nozzle that counts. And Lodding Nozzles have been engineered to give you the greatest possible showering efficiency, whether your system uses fresh or clarified white water.

Lodding Nozzles are designed with a built-in, sealed piston. In operation, pressure of the water forces the piston against the spray button, which is precision-milled to create the exact spray pattern desired — from an 80° fan to a needle stream.

As particles become lodged in the nozzle, the piston oscillates and automatically frees them. When the water is shut off momentarily the piston retracts. After the water is turned on again there is a brief period before the piston resumes contact with the spray button. During this interval larger particles are flushed from the nozzle.

It will pay you to investigate all the advantages of Lodding Self Cleaning Showers. Lodding, or one of our sales representatives, will be pleased to tell you more about them.





LODDING
Engineering Corporation
AUBURN, MASSACHUSETTS

THE *Pulp* YOU NEED

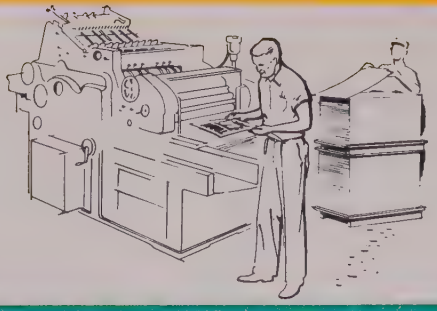
Where YOU NEED IT

When YOU NEED IT

A promise kept faithfully at Weyerhaeuser's Everett, Washington mill. This accounts for the round-the-clock operation that sends an endless chain of freight cars from coast to coast — to satisfy the demand for uniform quality pulp.

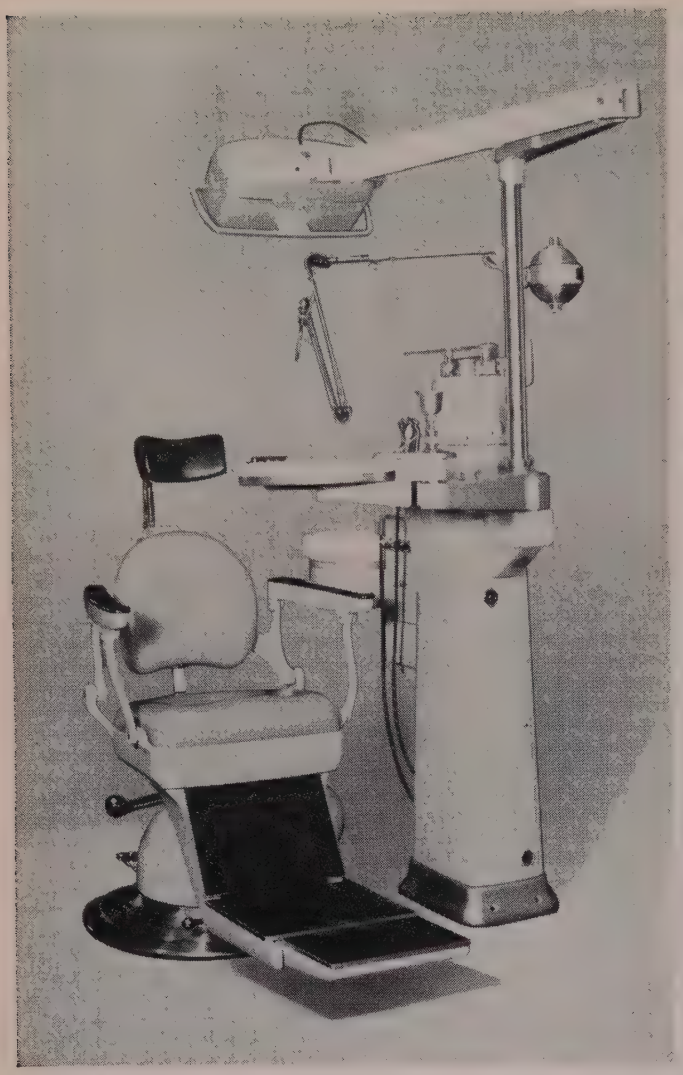
Today, all of Weyerhaeuser's modern mills stand ready to satisfy every request for:

- *Standard Bleached Sulphite*
- *Hardwood Bleached Sulphite*
- *Absorbent Alpha Bleached Sulphite*
- *Regular Bleached Kraft*
- *CD (Chlorine Dioxide) Bleached Kraft*
- *Soft Bleached Kraft*



PULP DIVISION

WEYERHAEUSER



DESIGNED BY VLADIMIR KAGAN FOR KAGAN-DREYFUSS, INC.

They're both chairs, but...

each is in a class by itself . . . like Wyandotte's PURECAL® O

These two chairs show what a vast difference a change of purpose can make. One is designed for comfort, the other for convenience . . . they're as far apart as pleasure and pain.

In calcium carbonates, too, differences become most significant in relation to their purpose . . . and all calcium carbonates are definitely *not* alike. Wyandotte PURECAL O is in a class by itself! Reason: Wyandotte's double refining — a unique reaction process — yields precipitated calcium carbonate of exceptional purity, uniformity, and whiteness. Particles are agglomerate-free, consistently cubical for best flow and leveling.

Each of these properties is essential for producing top-quality coated stock. For example, greatly improved gloss and finishing characteristics result from better particle packing and more uniform particle distribution in PURECAL O formulas.

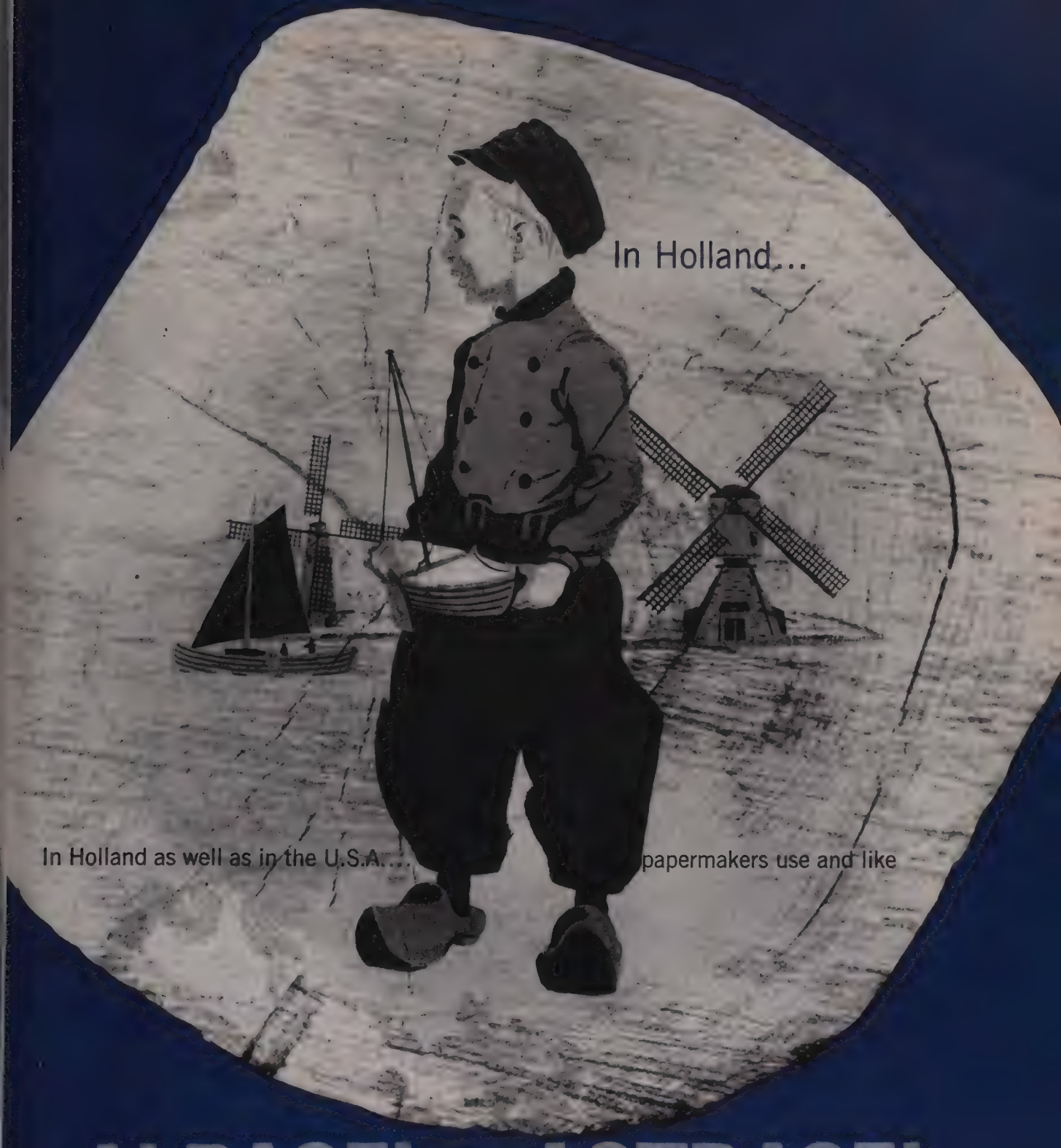
Why not evaluate the *multiple* benefits of PURECAL O in your own laboratory? Write for samples and technical data today. *Wyandotte Chemicals Corporation, Dept. 755-T, Wyandotte, Michigan. Offices in principal cities.*

WYANDOTTE CHEMICALS

Wyandotte CHEMICALS

MICHIGAN ALKALI DIVISION

PACING PROGRESS WITH CREATIVE CHEMISTRY



ALBACEL & ASTRACEL

CHLORINE DIOXIDE BLEACHED SOFTWOOD SULPHATE

CHLORINE DIOXIDE BLEACHED HARDWOOD SULPHATE

Balanced Paper-Grade Pulps Created by Papermakers for Papermakers

Throughout the free world, papermakers use and like Riegel's Albacel and Astracel . . . paper-grade pulps that provide the right balance of all important qualities: brightness, cleanliness, strength, formability and proper beating characteristics.

RIEGEL PAPER CORPORATION

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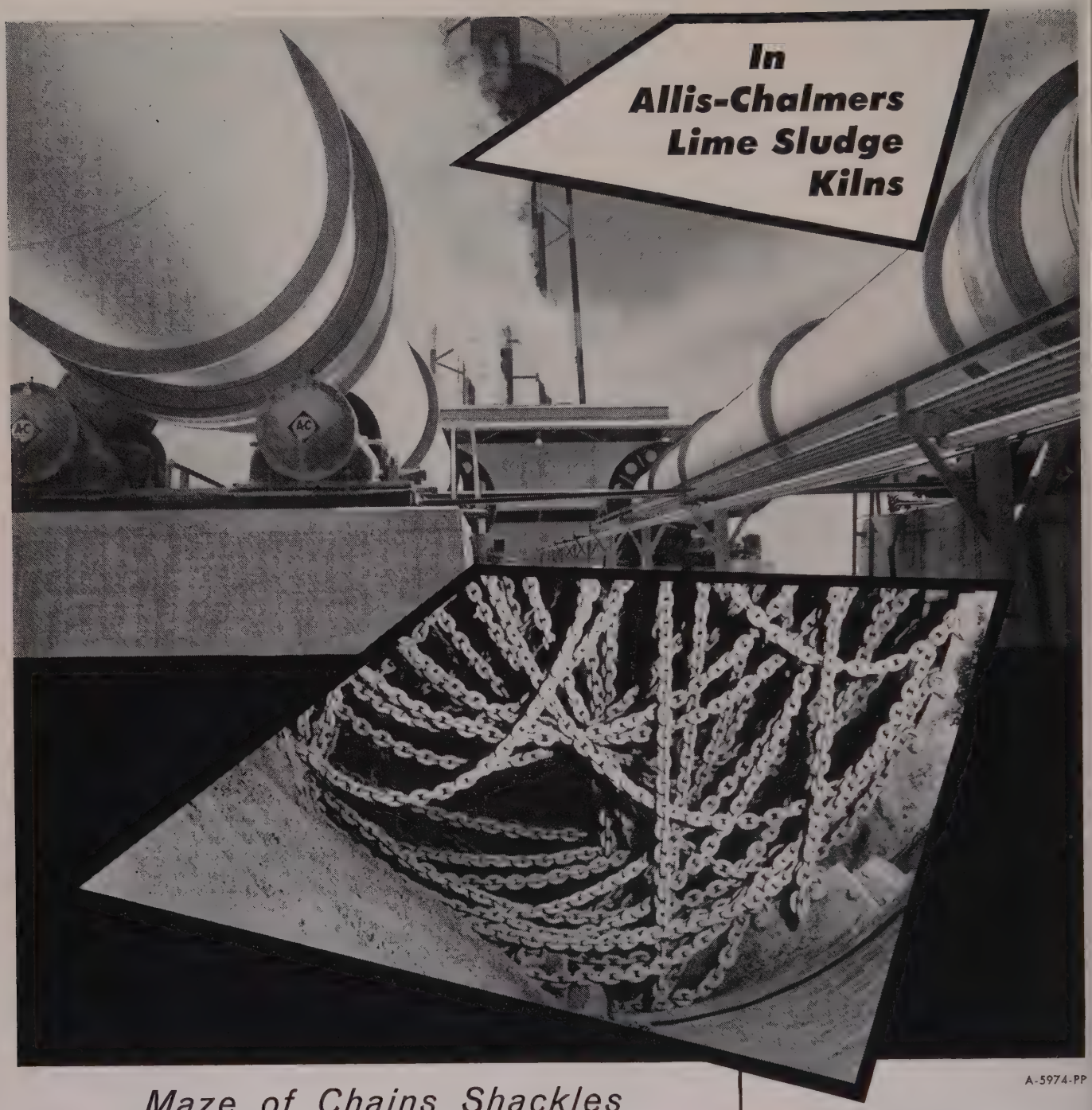


A-5974-PP

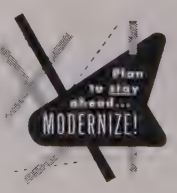
Maze of Chains Shackles Heat to Its Job

By effectively capturing and channeling heat, the Allis-Chalmers chain arrangement multiplies the profit advantages of lime recovery. Drying is accelerated in three ways:

1. Direct transfer of heat from chains to sludge.
2. Lifting material into path of hot gases.
3. Directing flow of gases over sludge bed under suspended chains.

Thermopruf chain offers further economies in lime sludge recovery. Patented *Thermopruf* links provide one third more heat transfer surface, withstand 40% higher temperatures, afford far greater resistance to corrosion than conventional chain. Call your A-C man for complete information or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

- **Speeds Drying**
- **Cuts Fuel Requirements 40%**
- **Increases Capacity**
- **Reduces Dust Loss**



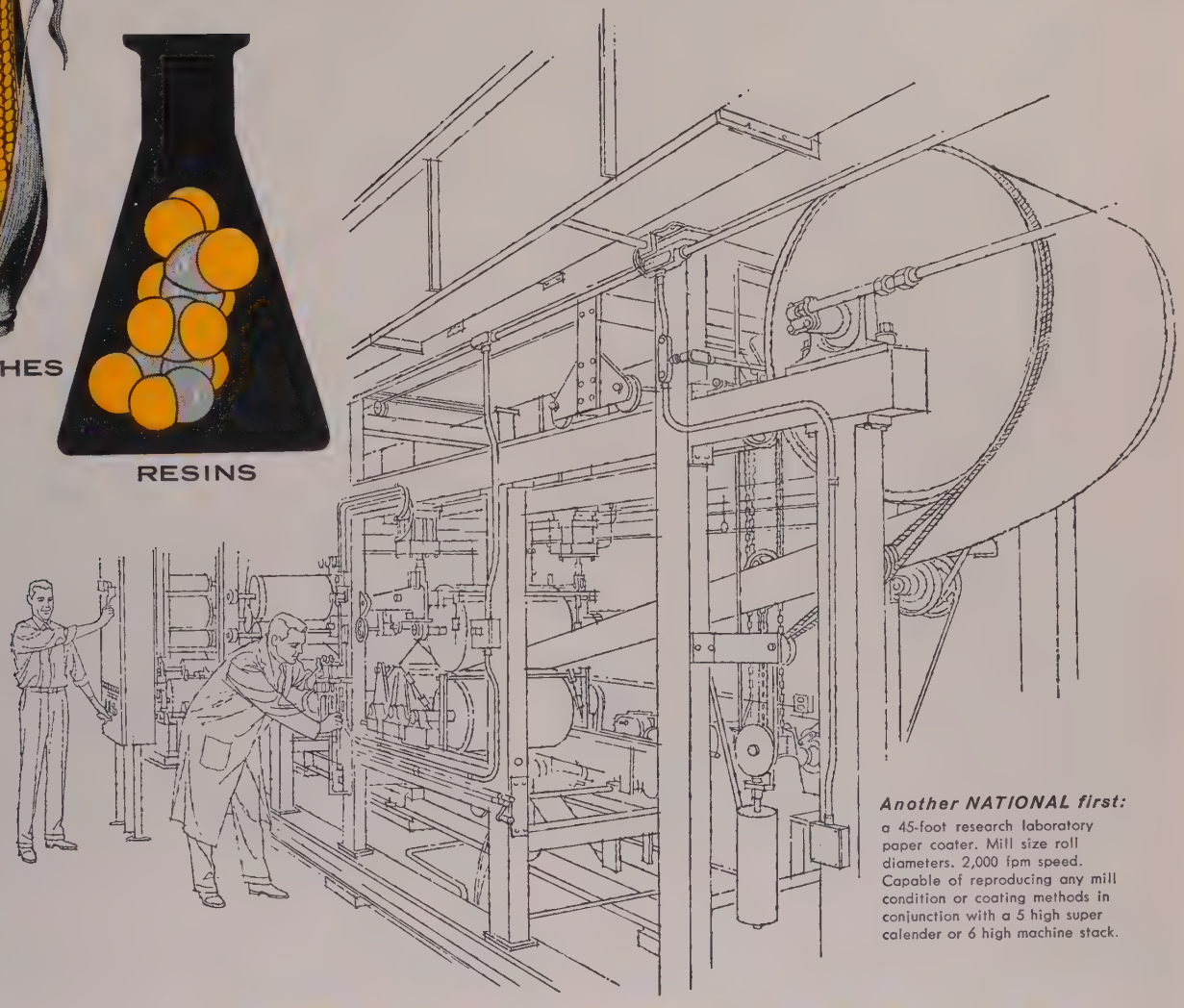
ALLIS-CHALMERS

"Cross Pollination"

GENETICS + SYNTHETICS + ADVANCED THINKING

STARCHES

RESINS



Another NATIONAL first:
a 45-foot research laboratory paper coater. Mill size roll diameters. 2,000 fpm speed. Capable of reproducing any mill condition or coating methods in conjunction with a 5 high super calender or 6 high machine stack.

Creates great advances in Paper Coatings

The genetic "cross pollination" of hybrid corn to produce unique strains . . . and the chemical "cross pollination" of corn starch to produce unique starch derivatives . . . plus "cross pollination" with vinyl acetate polymers and copolymers in emulsion form . . . have given NATIONAL complete flexibility of formulation in creating new and unique starch and resin coatings for paper. That's one great advantage.

An even greater customer advantage is NATIONAL's unmatched technical service. It's based on the "cross pollination" of our advanced thinking in paper coating research and our broad technical field experience.

Isn't it obvious that NATIONAL, who leads in research and serves the entire paper industry, can offer a wealth of know-how not generally possessed by individual paper companies?

This unmatched "cross pollinated" technical service is available for the asking . . . to help build unique product features that become decided competitive advantages.

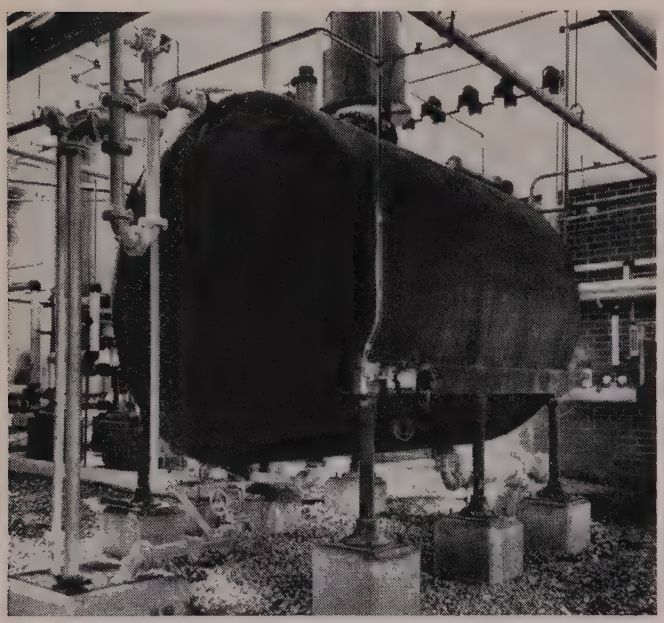
You'll find our coating binders and adhesives—everywhere!

National STARCH and CHEMICAL CORPORATION
750 THIRD AVENUE, NEW YORK 17, N. Y.

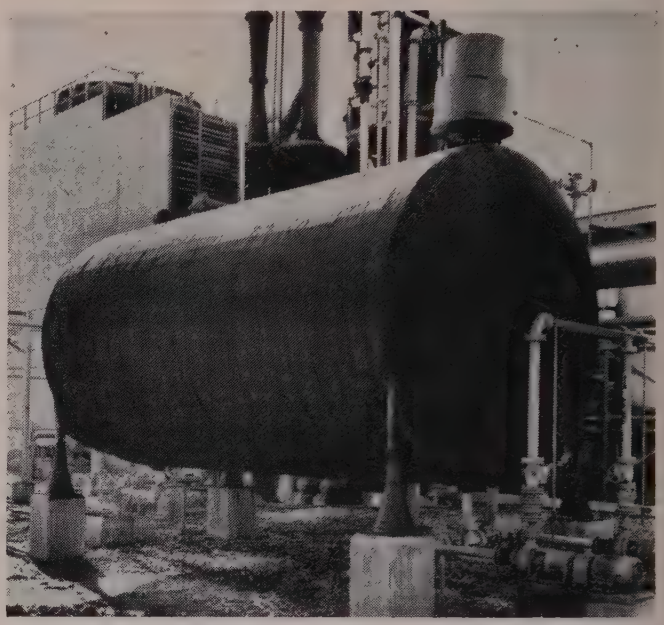
FLUIDICS

is a new PFAUDLER PERMUTIT program that provides a modern, imaginative approach for handling and processing more profitably the liquids and gases involved in such operations as:

corrosioneering	flow rate control	pumping	metering
water treatment	heat transfer	reactions	valving
waste treatment	fluid analysis	agitation	piping
		blending	storing



Waste liquors, highly corrosive, are accumulated in Glasteel at Marathon Southern in this 5000-gallon Glasteel Chemstor tank.



15,000-gallon storage tank of Glasteel construction keeps chlorine dioxide safe and pure until it's ready for use.

FLUIDICS AT WORK

How Marathon Southern uses Glasteel in chlorine dioxide generation

One of the major factors to consider in setting up a chlorine dioxide plant is the corrosiveness of chlorine dioxide itself and of the chemicals used to generate it.

Depending on the process you use, you run up against sodium chlorate, sulfuric acid, methanol, and sulfur dioxide.

One construction material is completely resistant to all and any combination of these chemicals . . . Pfaudler Glasteel.

That's why you'll find Glasteel equipment so much in evidence at Marathon Southern's new chlorine dioxide plant. This single material from one fabricator solves *all* the corrosion problems encountered.

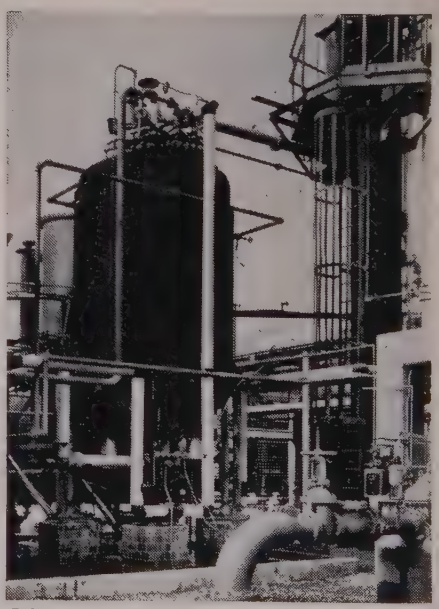
More than 35 pulp mills are now using Glasteel equipment for everything from generators to storage tanks and towers, from pumps and pipes to fittings and valves.

If you're considering a new chlorine dioxide plant or expanding or revamping an old one, take advantage of Glasteel, the modern material of construction for ClO_2 equipment, provided by our FLUIDICS program. You can get a complete analysis covering original prices, maintenance costs, and length of equipment life simply by contacting your Pfaudler representative.

Or write direct to our Pfaudler Division, Department T-89, Rochester 3, New York.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes



Primary chlorine dioxide generator at Marathon Southern. Five-ton-per-day capacity. Like most of the chlorine dioxide equipment at this installation, it's corrosion resistant Glasteel.

The need for a multi-use, low cost wet strength resin is answered in UFORMITE 711. This modified urea-formaldehyde resin may be used with both bleached and unbleached pulps. At low cost, this cationic resin provides wet strength for a wide variety of paper products from tissues to bag paper.

UFORMITE 711 saves time as well as money. It arrives at your mill in ready-to-use form. There's no formulating or premixing needed. Simply dilute UFORMITE 711 with water to the concentration most suitable for your processing procedures, and add it to the pulp system. Regular pH control with acid and/or alum means no change in normal mill procedures. While wet strength develops rapidly, fresh broke can be repulped readily.

If you're interested in these savings, you'll want a copy of the new technical booklet describing the use of UFORMITE 711 in papermaking, along with technical information on other UFORMITE wet strength resins by Rohm & Haas. Write for a copy.

Chemicals for Industry

ROHM & HAAS COMPANY

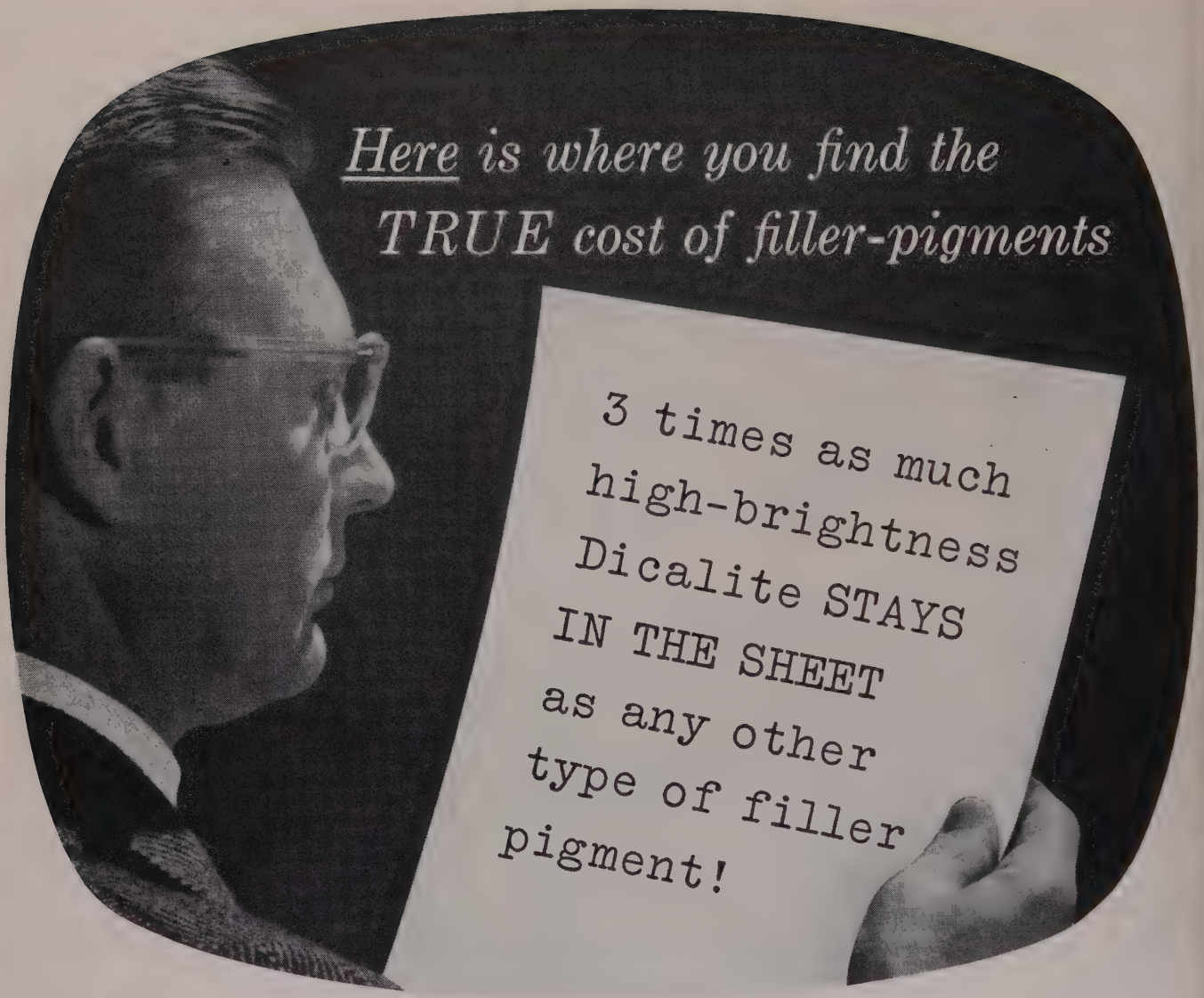
THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

UFORMITE *is a trademark, Reg. U.S. Pat. Off. and in principal foreign countries.*

UFORMITE 711



The true cost of any filler-pigment is cost per pound retained in the sheet—not cost per pound at the beater. And on that basis, high-brightness Dicalite Paperaids are the least expensive filler-pigments you can get.

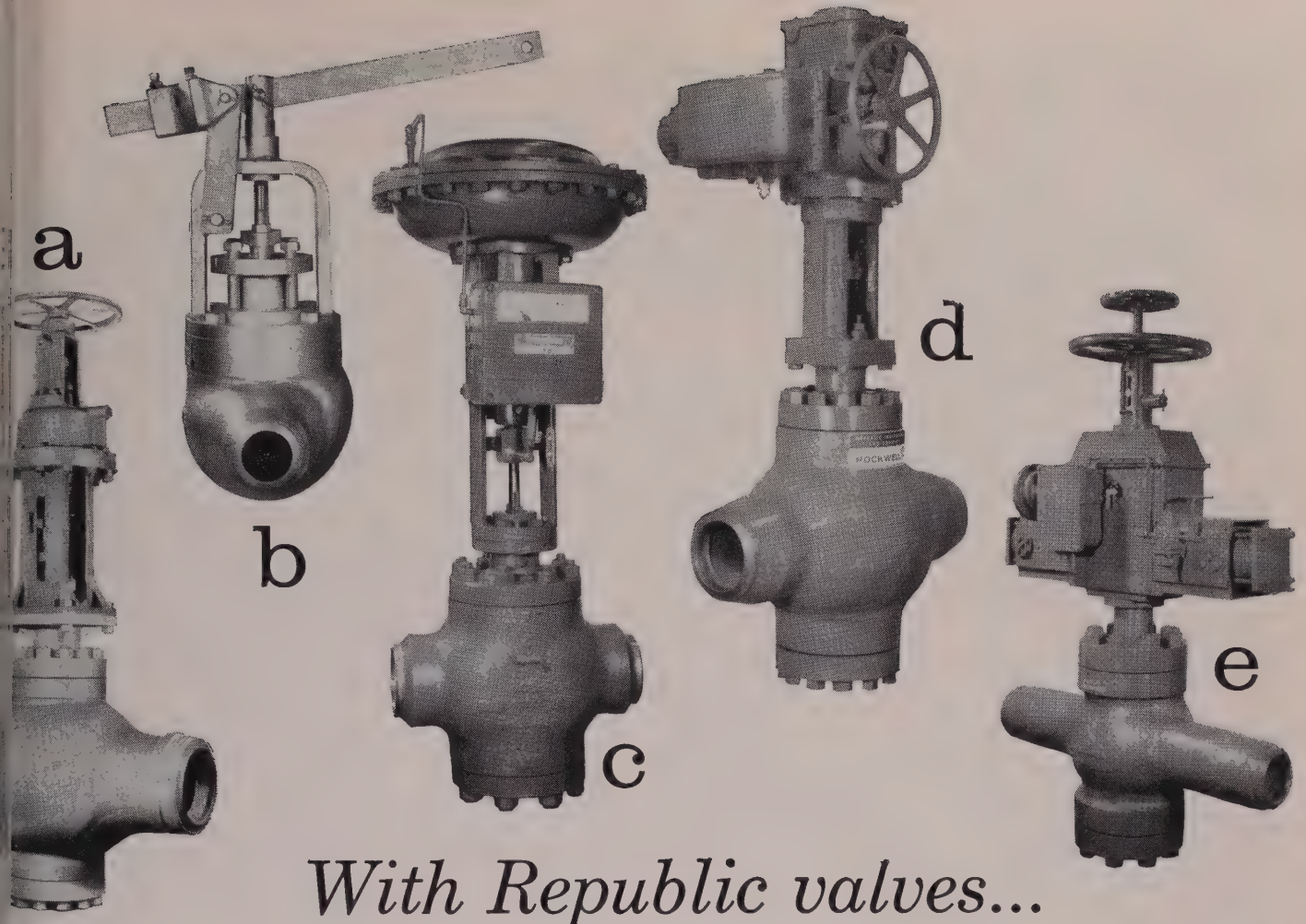
That's *fact*... proved in tests made in a leading paper mill on patent white and bleached manila furnish, with tests and furnish conforming strictly to TAPPI specifications. More high-brightness Dicalite BP-1 (89.6 on the G.E. scale) stayed in the sheet than any other filler-pigment. BP-3 and BP-5 did almost as well, and all three were far higher than TiO_2 or any clays tested.

These tests proved, once again, what many leading paper mills have long known ... that high-brightness Dicalite Paperaids will replace significant amounts of more expensive pigments such as TiO_2, with no loss in brightness, and give you a better, smoother sheet into the bargain—*all at lower cost!*

Dependable GLC GREAT LAKES **Dicalite**®

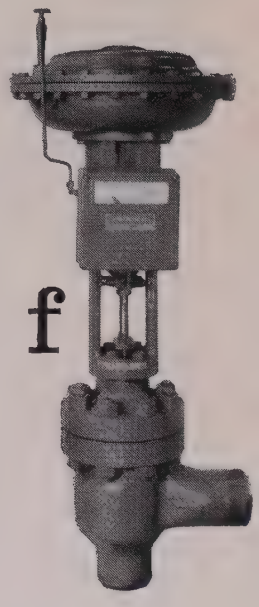
has many advantages in paper-making

For more information, write to **DICALITE DEPARTMENT** / Great Lakes Carbon Corporation • 612 So. Flower St., Los Angeles 17, California



With Republic valves...

You get longer life, less maintenance



For over 35 years Republic valve developments have paced the changing demands for more sturdy valves by the most progressive utilities and industries. For such services as pump recirculation control, feedwater regulation, steam pressure reducing and high pressure water control, Republic valves have established a reputation for durability, long life and trouble-free performance.

Superior valve design—Republic research into the causes of valve noise and vibration, and also the wear resisting and galling properties of materials has resulted in a modern line of Republic valves of advanced design. Republic valve contours are designed to produce not only the desired regulating characteristics but also to reduce erosion damage and noise as well. Extra large guide bushings, extra deep stuffing boxes, solid plug inner valve construction, plus precise manufacture and long-life materials make Republic regulating valves perform better, last longer, with less maintenance.

Wide selection of valves and features—Rockwell-built Republic regulating valves shown on this page are representative of the complete Republic line:

a. **Cylinder operated valve**
b. **Lever operated valve**
c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

And, for many special applications, such Republic accessories as pneumatic and electric valve positioners for hysteresis-free control, and a complete line of controllers are available.

Whatever your regulating valve problem, let Republic engineers put their years of application experience to work for you. For additional information, see your Republic representative, or write to Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois.

REPUBLIC INSTRUMENTS AND CONTROLS

more fine products by

ROCKWELL

AN EBASCO-BUILT PAPER MILL
IS DESIGNED TO

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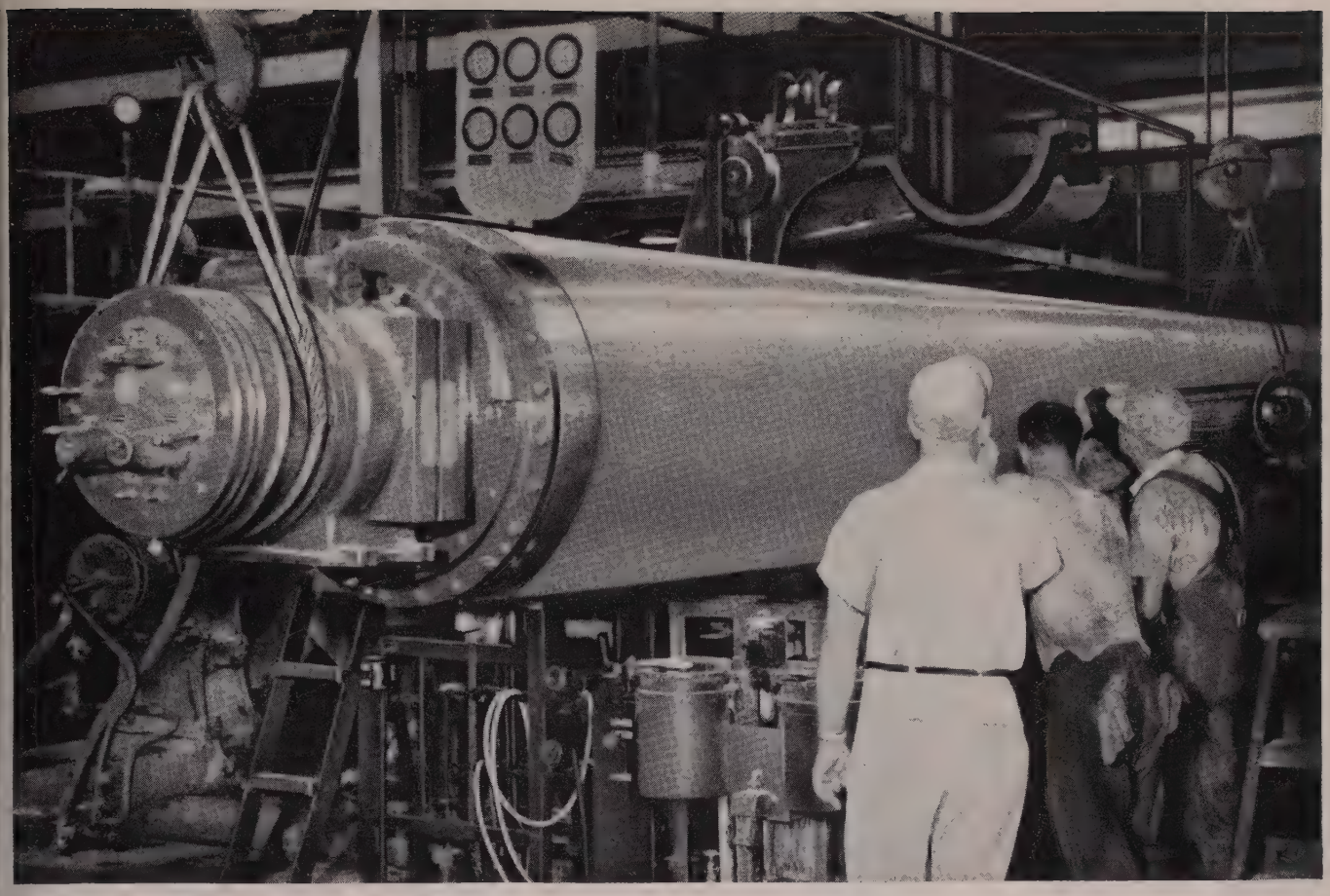

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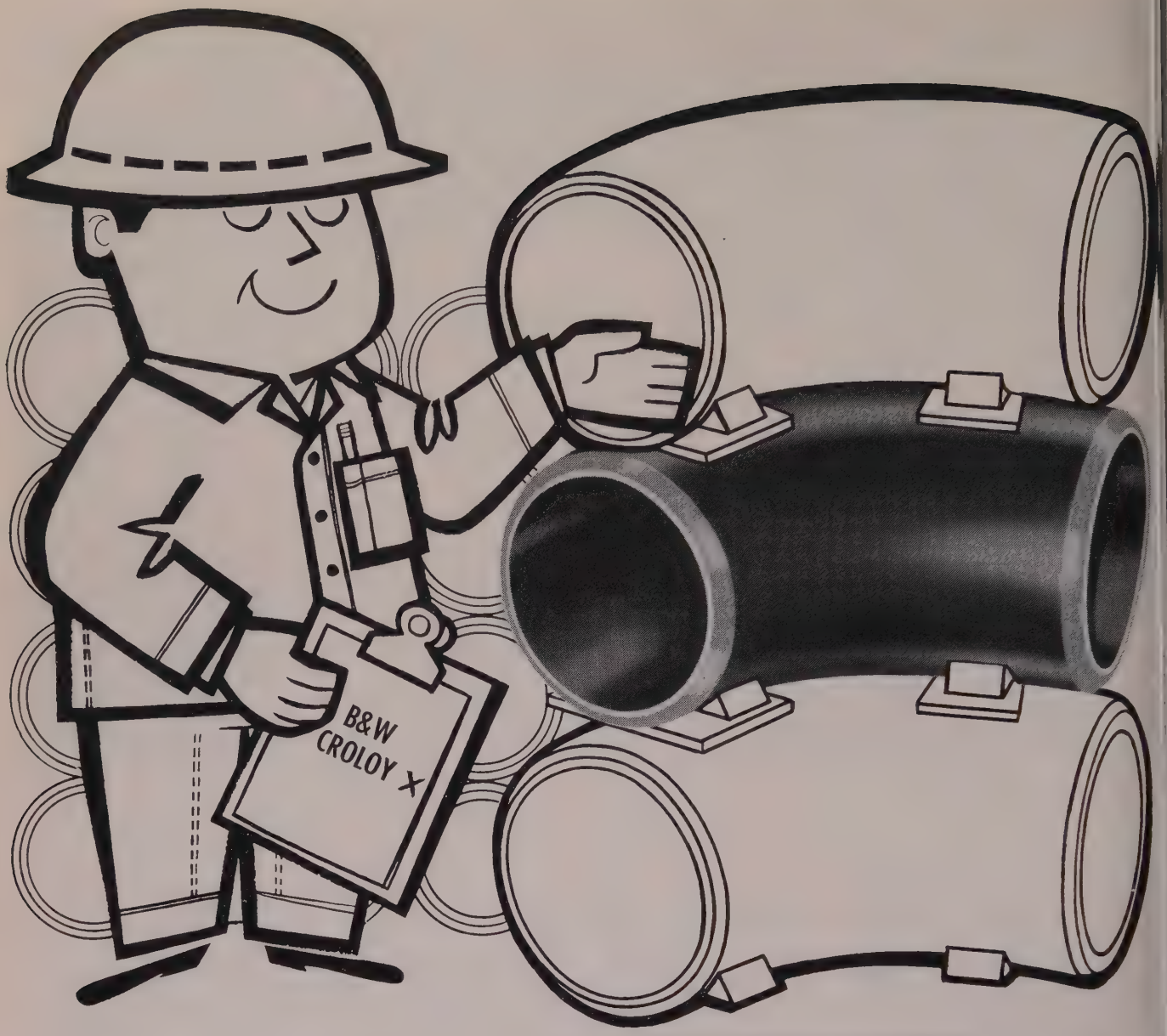

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Description and Measurement of White Surfaces

RICHARD S. HUNTER

This is the report of Inter-Society Color Council Subcommittee on Problem 19 formed in 1953 to study the color technology of white surfaces. Physically, surfaces which appear white reflect strongly and diffusely throughout the visible spectrum. Psychophysically, whites occupy a volume without sharply defined boundaries in the top center of the color solid. Measurements and intercomparisons of the colors of whites are made to determine adequacies of match to standard and to determine compliance with color specifications. One-number reflectance measurements of whites are widely used as partial specifications of the colors of whites. Whiteness is the attribute of white surfaces corresponding to their visual proximity to preferred white. Preferred white tends to vary with change of either the observer or the observing situation. In spite of the somewhat nebulous character of whiteness, a number of formulas have been proposed for its measurement by combining the effects of grayness and yellowness. Studies of visual ratings indicate that yellowness detracts from whiteness about four times as much as does grayness measured by the same reflectance increment.

This is a report by Inter-Society Color Council Subcommittee on Problem 19, White Surfaces. Among the 27 professional societies joined with TAPPI in the ISCC are at least 13 actively concerned with the description and measurement of the whiteness and other color attributes of the materials with which they deal.

WHITE COLORS AND WHITENESS

White is ordinarily perceived as a unique color different from other colors of surfaces. This visual uniqueness of white is the basis for the following definition: A white surface is one which appears white when seen in its normal surroundings. There are, of course, a variety of whites and no fixed line of demarcation between white surfaces and light-colored near-white surfaces. Figure 1 is a drawing of a surface-color solid which shows by dotted line approximately that part of the top center of the solid in which are represented colors called white.

Whiteness is that attribute of a white surface which denotes its similarity in color to some preferred white. Since the preferred white differs with observer (*1*, *2*), the observing situation, and with the fashions of time, whiteness is not a specific fixed attribute of surfaces.

Physically, a white surface is one which reflects strongly throughout the visible spectrum (usually more than 50%). The higher and more uniform the spectral reflectance, the whiter the surface appears. As examples of white surfaces, a porcelain panel, a sheet of newsprint, a swatch of white cotton broadcloth, and a panel of semigloss wall paint were measured with the GE recording spectrophotometer (*3*). The curves of these specimens in Fig. 2 show that, as would be expected, the newsprint is the least white of the four. The cotton and enamel are of about the same whiteness yet spectrally they are different. One could not decide which was the whiter from the curves in Fig. 2 until he had specific colorimetric criteria for the judgment of whiteness.

White materials are most likely to depart from preferred white in the yellow and gray directions. Organic materials will, in general, have spectrophotometric curves sloping downward in the blue like the curves for the newsprint paper and the interior paint shown in Fig. 2. This reduced reflectance in the blue causes the surfaces to appear yellowish.

Geometrically, a white surface is one which reflects diffusely in all directions. Curves obtained for the same four specimens with the Hunterlab recording goniophotometer are shown in Fig. 3. It can be seen that everyday white surfaces depart substantially from their traditional uniformity of directional reflectance in different directions. These departures are in addition to the differences in geometric reflectance centering in the specular direction which are associated with gloss and are unrelated to whiteness. This geometrical variability of the reflectances of whites is sometimes responsible for troublesome discrepancies between results from different instruments used to measure them. In the paper industry for example, it is one source of disagreement between different reflectometers used for brightness measurement.

For specifications of color, three numbers are used for whites as for other colors. Whites can be specified by their CIE coordinates Y, x, and y, by dominant wavelength, purity, and luminous reflectance, or by

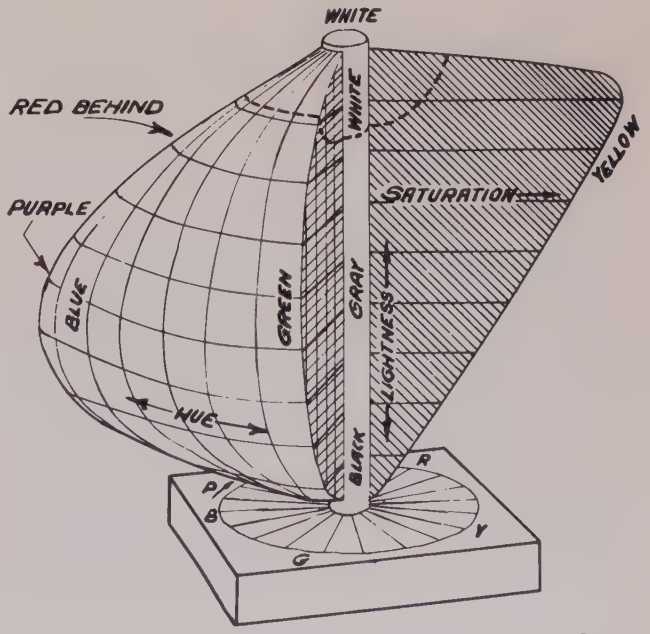

Fig. 1. The surface-color solid with dotted lines enclosing approximately that volume at the top which contains white colors

RICHARD S. HUNTER, Hunter Associates Laboratory, Inc., McLean, Va.

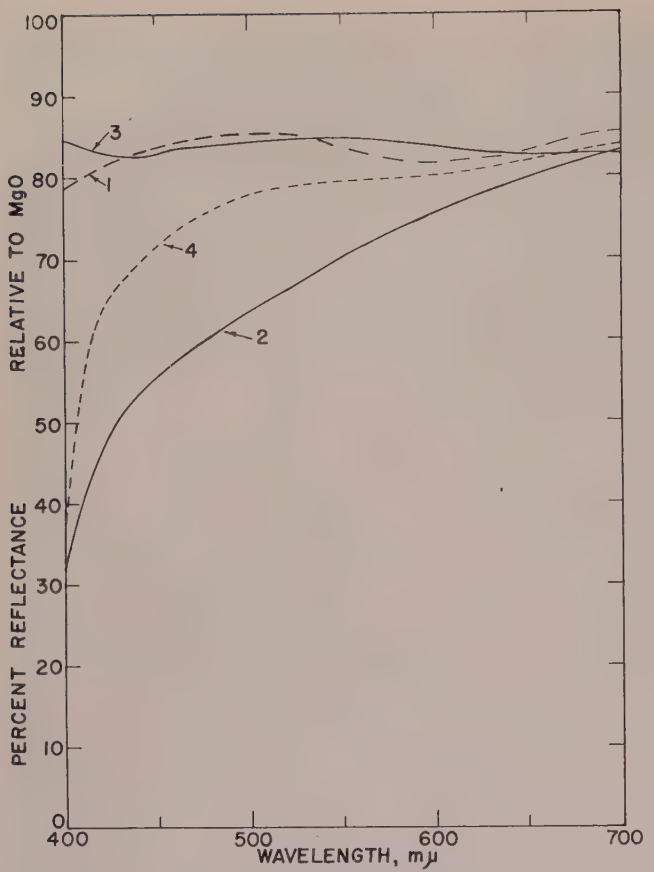

Fig. 2. Spectrophotometric curves for four white surfaces selected at random: (1) cotton broadcloth, (2) newsprint paper, (3) porcelain enamel, (4) interior paint

their Munsell notations which correspond closely with the respective hue, saturation, and lightness dimensions of the psychological color solid in Fig. 1. In practice, the Munsell-system intervals are somewhat too large for the satisfactory identification of all the different white colors in which there is interest.

The dimensions of the rectangular color solid illustrated in Fig. 4 by a horizontal cut through the center are widely used for the specification of white colors. These dimensions are (1) lightness, which is the same vertical dimension as in Fig. 1; (2) a, which measures degree of redness when plus $(+a)$ and degree of greenness when minus $(-a)$; and (3) b, which measures

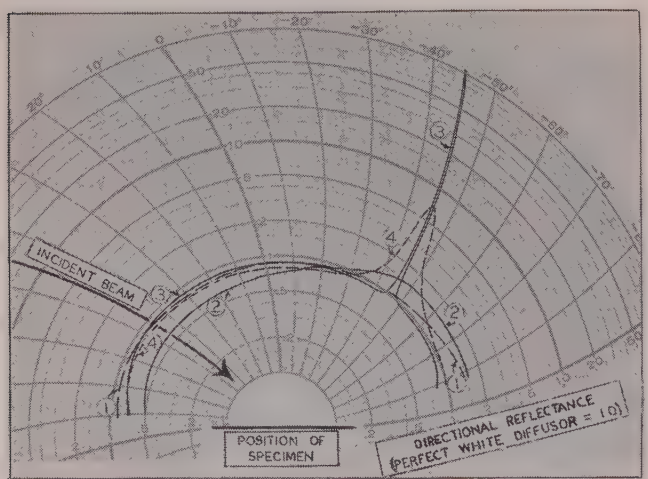

Fig. 3. Goniophotometric curves for 45° incidence of same specimens used for Fig. 2: (1) cotton broadcloth, (2) newsprint paper, (3) porcelain enamel, (4) interior paint

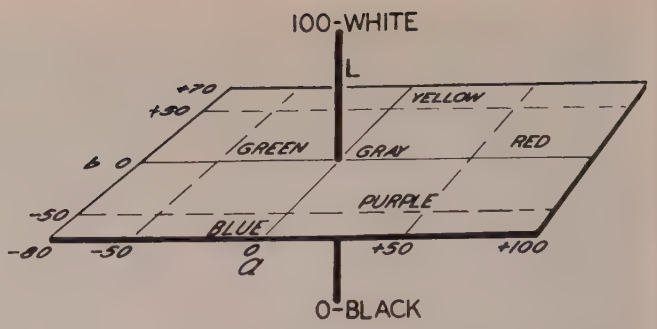

Fig. 4. The rectangular surface-color solid with dimensions L, a, and b

degree of yellowness when plus $(+b)$ and degree of blueness when minus $(-b)$.

The two rectangular chromatic dimensions, yellowness-blueness and redness-greenness, correspond closely to visual impressions of differences between white colors. The rectangular coordinates of the solid (*4*, *5*) are generally more convenient for computing small color differences than are the polar coordinates of the Munsell solid. The L, a, and b, values of color may be read directly with one type of photoelectric tristimulus colorimeter (*5*) and may be computed easily from readings on a number of tristimulus reflectometers.

Actually there are several different sets of L, a, and b dimensions, each related to the CIE system by slightly different equations. These different scales exist because different data on perceptual uniformity were used in their various developments and because they were designed for convenience in use with different instruments in different use situations.

VISUAL EXAMINATION OF WHITES

In Fig. 5 are shown three arrangements used commercially for the visual examinations of white colors. The first two arrangements are used both for examining adequacies of match to standard whites and for visual intercomparisons and estimates of whiteness. The third is used largely for whiteness evaluations. Standardized artificial light sources and inspection cabinets are popular but those with close spectral rendition of natural daylight are costly both in capital outlay and power consumption; others do not give close spectral rendition of natural daylight. The latter, preferably from the north sky, is still used for many if not most visual color examinations.

As is shown in Fig. 5, it is possible with nonrigid white materials to enhance hue by multiple reflections within cavities of the material being studied. In practice, inspectors use all clues available to them and

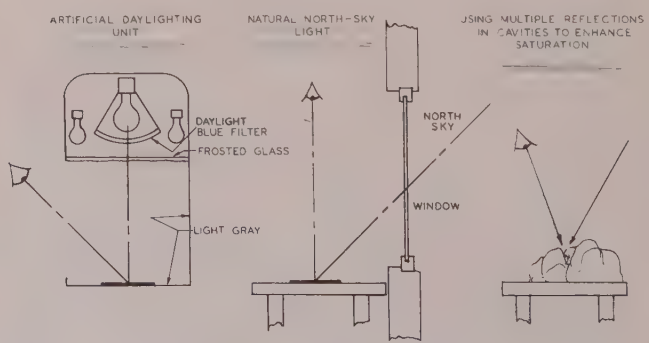

Fig. 5. Three lighting arrangements used for visual examination of white materials

Table I. Commercial Instruments Regularly Used for Color Measurements of Whites

Instrument and manufacturer	*Geometry*	*Illuminant color*	*Remarks*
1. Spectrophotometers			
G. E. recording (*3*) (General Electric Co., Schenectady, N. Y.)	Near normal diffuse	Any	Plots curves automatically. Tristimulus integrator may be added
Beckman Model DU (*6*) (Beckman Instruments, Fullerton, Calif.)	45°0°	Any	Wavelength and standard value set before each reading
2. Abridged (filter) spectrophotometers			
Institute of Paper Chemistry brightness tester (*7*) (Appleton, Wis.)	45°0°	Incandescent	Used chiefly for blue reflectance but possesses other filters
Welch Densichron (Welch Scientific Co., Chicago, Ill.)	45°0°	Incandescent	Widely used in printing industry
3. Tristimulus filter reflectometers			
Hunter multipurpose (*8*) (Hunter Associates Laboratory, (*9*) McLean, Va., and Gardner Laboratory, Bethesda, Md.)	45°0°	Daylight	Convenient only for whites and light colors
Photovolt Model 610 (Photovolt Corp., New York, N. Y.)	45°0°	Daylight	Low cost. Small search unit movable to test surfaces
Color eye (Instrument Development Laboratories, Needham, Mass.)	Near normal diffuse	Daylight or lamplight	Good comparator, particularly for dark specimens
Colormaster differential colorimeter (*10*) (Manufacturers Engineering and Equipment Company, Willow Grove, Pa.)	45°0°	Daylight	Good stability, precise comparator
(4) Trichromatic colorimeter			
Hunter color-difference meter (*5*) (Hunter Associates Laboratory, McLean, Va., and Gardner Laboratory, Bethesda, Md.)	45°0°	Daylight	Reads color directly on L, a, b "uniform color scales"
Nickerson-Hunter cotton colorimeter (*11*) (Special Instruments Laboratory, Knoxville, Tenn., and Gardner Laboratory, Bethesda, Md.)	45°0°	Daylight	Reads luminous reflectance and (yellowness) automatically

all the techniques they have developed from past experience in making color examinations of white materials. They are frequently unaware of the mechanisms by which they make these judgments even though these judgments are, in general, surprisingly acute.

The perceptibility of color differences between whites varies with illuminant differences. Differences in the yellowness of near-white surfaces are due to differences in absorption of blue light. Relatively, daylight illuminants have two to five times as much energy in the blue as do incandescent illuminants. The eye is therefore much more sensitive to yellowness differences in daylight than in incandescent light. In other words, differences in the b dimension of Fig. 4, which are readily seen under illuminants rich in blue, are not seen under yellowish illuminants. This is one of the reasons why bluish illuminants are selected for the visual inspection of whites where yellowness differences are important. (Examples: 7500° K. artificial daylight is now standard for color inspection of raw cotton and color printing on white paper.)

INSTRUMENTS USED TO MEASURE WHITE SURFACES

By comparison with the eye, instruments for rating white surfaces have a great advantage in that they furnish recordable and repeatable numbers rather than mere mental impressions. However, instruments have little if any advantage over the eye in chromatic sensitivity. With many of them, moreover, readings have to be transformed by more or less complex computational procedures to provide numbers corresponding to visual appearance.

Instruments used to measure color of whites are of four types: (1) spectrophotometers, (2) abridged (filter) spectrophotometers, (3) tristimulus (filter) reflectometers, and (4) trichromatic colorimeters. Figure 6 shows by block diagrams the basic differences between these types. Table I lists today's most popular color-measuring instruments of each of these types. All are photoelectric.

None of these color measuring instruments now available is importantly better than the human eye in ability to detect certain small color differences. Although differences in the vertical dimension of the color solid can easily be measured with precision exceeding that of the eye, horizontal differences cannot be measured with the same precision. For the red-green dimension, it is necessary that tristimulus reflectometers and colorimeters detect signal changes of only 0.03% of the signals being measured to equal the best eyes in ability to see color difference.

A spectrophotometer uses a prism as suggested in Fig. 6 or a grating to isolate wavelengths of the visible spectrum. It gives curves, as shown in Fig. 2, of reflectance as a function of wavelength.

A filter reflectometer or colorimeter uses filters instead of the prism or grating in a spectrophotometer to isolate different wavelengths. It is not possible with filters to isolate spectral bands as narrow as with a spectrophotometer. There are two types of filter in-

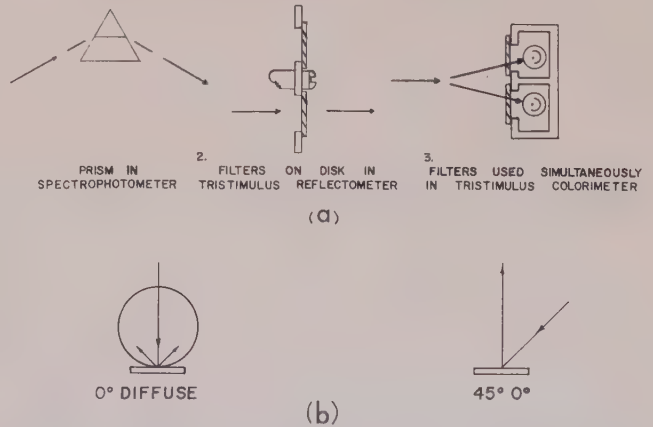

Fig. 6. Diagrams of wavelength-selecting devices and geometric instrument types used in color-measuring instruments

struments: (1) the abridged spectrophotometer in which the filters isolate fairly narrow (20 to 70 mμ) spectral bands, and (2) tristimulus reflectometers. The latter require filters transmitting rather broad spectral bands corresponding to the spectral response functions of the CIE-standard observer. Figure 7 shows the spectral character of the source-filter-photocell combinations used for tristimulus measurements of white surfaces.

Colorimeters give not values of reflectance, but numbers corresponding to position in the color solid. For example, Hunter's photoelectric color and color difference meter (*5*) gives results directly in the *L*, *a*, and *b* dimensions of Fig. 4.

As will be seen from Table I and Fig. 6, there are geometric as well as spectral differences between instruments used to measure color. For reflectance work, commercial instruments use either a near normal-diffuse or a 45°0° geometry. The 45°0° geometry is advantageous where it is necessary to avoid specular reflectance (responsible for gloss) in the measurement of color. The diffuse geometry is more efficient in light utilization. Results with it do not vary with rotation of a textured specimen in its own plane as do those with the 45°0° geometry.

COLOR EVALUATIONS OF WHITES

As shown above, complete evaluations of white colors must be tridimensional in character. Such evaluations are involved where one is concerned with matches to standard or compliance with color specifications. Many useful measurements of white colors, however, are only one- and two-dimensional. Reflectance measurements involving individual tristimulus filters are widely used for processing and quality controls. Paper brightness measurements of blue reflectance and opacity measurements of luminous-reflectance ratios fall in this category. Two dimensions, luminous (green) and blue reflectance, are generally adequate for appraisals of whiteness. These measurements of proximity to preferred white are, at the present time, used chiefly in research studies of product quality and possible new products.

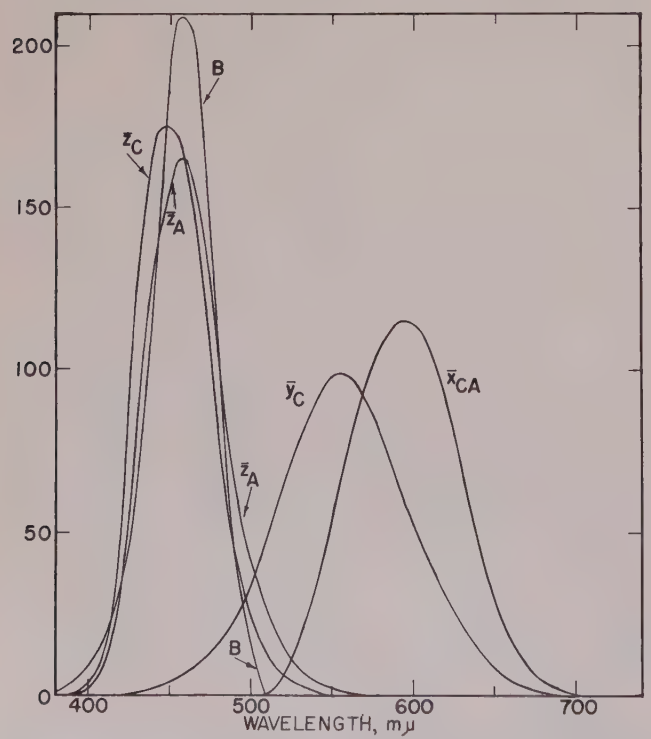

Fig. 7. Spectral character of five source-filter-photocell combinations used for color measurements of white surfaces

Matches to Standard

In the commercial production of many whites, color uniformity of product is as important a goal as good whiteness. Thus, all the paper used in a single book, the collars and body pieces used to make a man's shirt, or the white paint and porcelain enamel used for the household appliances which will be assembled in a kitchen should, in each case, have a uniform white color.

Industrial color matching of whites is still done largely by eye, although instruments and numerical color tolerances computed from their readings now enjoy some use. With most materials of commerce, the tolerances are small. For example, a mail order house which issues a standard white panel for the color of kitchen appliances requires that the color of this panel be matched to tolerances which average $\Delta Y = \pm 0.015$, $\Delta x = \pm 0.0025$, $\Delta y = \pm 0.003$. To have the precision necessary to establish conformity to these small tolerances, instrument measurements must be made with care.

There is still no agreement on how best to obtain and maintain permanent standards for the visual color matching of impermanent materials. For papers, textiles, foods, and other impermanent materials, careful instrumental measurements are used to follow the color drift of standard samples so that the users of standard samples of these materials know how best to maintain them and how long to trust them for color permanence. Permanent ceramic standards are sometimes sought to match the colors of these impermanent materials. However, the texture differences in appearance between ceramic and nonceramic materials frequently make visual color comparisons difficult. Where instruments are used to measure impermanent white materials by reference to permanent white standards, the problems of intercomparing surfaces of different texture largely disappear. It is partly for this reason that the use of instruments for color matching of whites is growing.

Color Specifications

Unfortunately, there exist no well-standardized assortments of white chips like the colored chips of the Munsell color system and Container Corp. Color Harmony Manual. There is thus no organized system with which to specify white colors by closest visual match. One who wishes to specify a white color is limited to specifications based on instrument measurements unless he is in a position to prepare and supply his own standard white chips.

Color specifications for whites may employ the conventional standard coordinates of the CIE system. Thus, American flags purchased by the Federal Government are required by Federal Specification TTC-591 to visually match a white color specified by $Y = 0.57$, $x = 0.32$, $y = 0.33$ relative to magnesium oxide under CIE illuminant C. However, many whites are specified in the *L*, *a*, *b*, and other coordinate systems. Thus, the

Table II. Reflectance Measurements of White Colors

	Applications	*Paints and plastics*	*Papers and printing*	*Textiles and detergents*	*Ceramics*
Luminous reflectance (Green light) ($\bar{y}$c, Fig. 7)	Efficiency of surfaces used to reflect light (*12, 13*)	X		X	X
	Cleaning efficiency measured by gray soil removal			X	
	Opacity by contrast-ratio method (*13, 14*)	X	X		X
Blue-light reflectance (B and $\bar{z}_A$, Fig. 7)	Degree of bleach and chemical purity (*15, 16*)		X	X	
	Brilliance attainable by dyeing or color printing		X	X	
	Effectiveness of fluorescent whiteners (measure with UV in illuminant)		X	X	

quality control department of a soap manufacturer requires that a white detergent powder which it markets have the color specified by $L = 93$ min, $a = 0 \pm 1.0$, $b = 3.0 \pm 1.0$. This sort of specification is, of course, intended for use with a tristimulus colorimeter or reflectometer. Tristimulus instruments are widely used for whites because the spectral errors to which tristimulus instruments are subject are minimized by the lack of spectral selectivity characteristic of whites.

Reflectance measurements of whites are widely made with one or another of the tristimulus filter-photocell combinations shown in Fig. 7. Different filters and different instruments have been adopted by custom and use in different industries. The most commonly used reflectance methods for whites involve luminous (green) or blue reflectance. They are identified in Table II together with the materials for which they are used and the aspects of whiteness each is designed to measure. A number of these industry-wide, one-number reflectance methods for white materials have been used for many years and are firmly established in processing and quality control. None of them provides a complete measurement of color because none involves the three determinations necessary.

Luminous reflectance measurements with the $\bar{y}_c$ (green) combination in Fig. 7 are used for detergency studies of soaps, of cleaning agents and of the machines which perform the cleaning. Textile swatches artificially soiled to a gray color are measured before and after controlled cleaning operations. The gain or percentage gain in reflectance of each swatch is used as a measure of the effectiveness of detergent, cleaning process, or combination.

For paints used on interior walls, and ceramics and plastics employed in lighting units, luminous reflectance measurements are used to measure light-conserving efficiency. Paints are widely specified by minimum acceptable luminous reflectance. There are ASTM and Federal standard methods of test for their measurement (*12, 13*).

Luminous reflectance measurements are employed for opacity evaluations of paper, paint, and porcelain enamel. Films of these materials are measured for opacity by the contrast ratios of their luminous reflectance when backed by black, divided by that when the same films are backed by white. The paint, paper, and ceramic industries, and the Federal Government have standard reflectance methods for opacity measurement (*13, 14*).

Blue reflectance, or brightness, is widely used in the paper industry for two reasons:

1. Since white papers normally have poorest reflectance in the blue region of the spectrum, blue reflectance gives a combination measure of the freedom-from-grayness and freedom-from-yellowness components of whiteness.

2. Blue reflectance measures the freedom of finished papers from the yellowish impurities which are removed by bleaching. It therefore correlates with the completeness of bleaching and with paper permanence.

Blue reflectance measured under specified standard conditions is a technical quantity termed "paper brightness" in the industry. It is used commercially for the specification of many paper raw materials as well as for finished papers. A test method, which is now standard for the Technical Association of the Pulp and Paper Industry (*15*), uses the blue-light spectral distribution labeled B in Fig. 7. Calibrated standards for this test are regularly circulated through the paper industry by The Institute of Paper Chemistry of Appleton, Wis. The spectral distribution specified by the ASTM method for paper brightness (*16*) measurements is somewhat different, being the CIE $\bar{z}$ function for illuminant A (curve $\bar{z}A$ in Fig. 7).

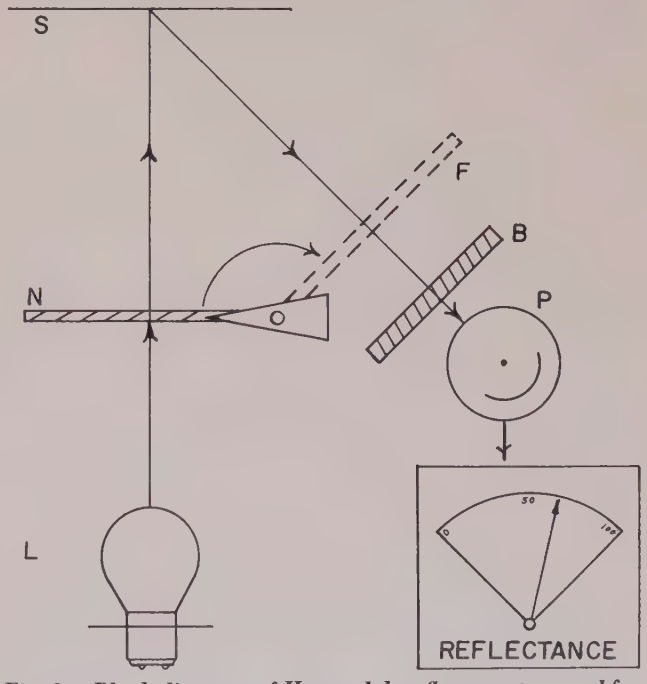

Fig. 8. Block diagram of Hunterlab reflectometer used for measurement of fluorescence contribution to blue reflectance: L—lamp, N—ultraviolet absorbing filter before specimens, S—specimen, F—same filter after specimen absorbing reflected ultraviolet, but not ultraviolet converted to blue by fluorescence, B—blue filter, and P—photodetector

Blue reflectance measured under the proper conditions can be made to evaluate still an additional factor of commercial interest to the textile and paper industries. The so-called optical bleaches are dyes now widely used to enhance whiteness by ultraviolet-stimulated fluorescent blue light which supplements the normally deficient natural blue reflectance. Whether an instrument responds to this fluorescence depends on whether the ultraviolet absorbing filter is ahead of, or behind the specimen in the light path from source, to specimen, to photodetector. Although instruments normally use incandescent rather than daylight illumination, these incandescent lamps normally possess enough of the near ultraviolet, which stimulates these brighteners, to make them useful in brightener evaluation.

A reflectometer of the type shown in Fig. 8, in which the ultraviolet absorbing filter is movable from incident to viewing beam, may be used to measure the actual contribution of a fluorescent brightener to blue reflectance. With it one can measure reflectance both with and without the fluorescence contribution.

Whiteness, or visual proximity to preferred white, is an attribute useful for product evaluation and research. The problem of how to obtain numerical values of whiteness from tristimulus values has received attention from a number of investigators during the past 25 years. MacAdam (*17*), Judd (*1, 2*), Harrison (*18*), Hunter (*19*), and Selling and Friele (*20*) have all proposed formulas or colorimetric procedures for reducing colorimetric specifications of white colors to a single-valued measure of whiteness. Asmussen and Buchmann Olsen (*21*), Selling and Friele (*20*), Hutchins, Stearns, and Sundstrom (*22*), Hemmendinger and Lambert (*23*), and MacAdam (*24*) are among the many who have intercompared whiteness formulas for different applications. The formulas which have appeared to date have not enjoyed general usage, probably because they seem too complex for routine application.

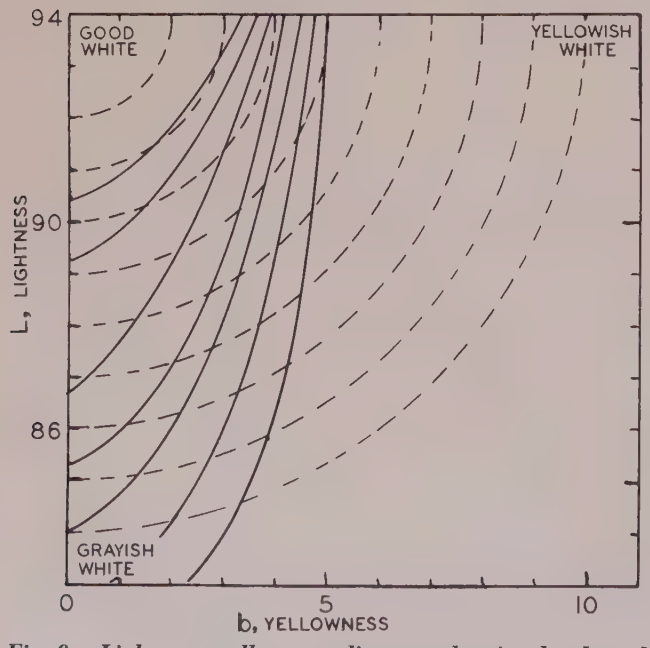

Fig. 9. Lightness-yellowness diagram showing by dotted quarter circles colors of equal whiteness by the Hunter equation (5), and by solid lines colors of equal whiteness according to MacAdam (17)

The question of how properly to measure whiteness is largely one of how properly to assess the contributions of luminous reflectance measured by tristimulus Y value (green reflectance) and of yellowness measured by luminous reflectance minus blue reflectance. In general, X tristimulus value associated with red reflectance contributes negligibly to whiteness.

A formula for whiteness which has enjoyed some use is based on the assumption that equal distances between points in the L, a, and b color solid of Fig. 4 represent differences of equal perceptibility:

$$W = 100 - [(100 - L)^2 + b^2]^{1/2}$$

Sometimes L_p, the lightness of the preferred white of whatever material is under study, is substituted for the second "100." This has the effect of changing from an ideal to an actually attainable preferred white. If one studies comparative whiteness rankings made under standard observing conditions with tristimulus values for the same white surfaces, he finds that such an equation for distance in Euclidean color space does not accurately represent visual whiteness rankings. Figure 9 is an L, b diagram on which are drawn: (1) concentric quarter circles corresponding to whiteness ratings by the foregoing equation and (2) loci of equal whiteness ranking obtained by MacAdam (*17*). It will be seen that the relation between yellowness (b-scale value) and whiteness is nonlinear. It would appear from MacAdam's experiments that when yellowness (b) exceeds a certain minimal value, it interferes strongly with whiteness acceptability. Because it can eliminate this yellowness, the use of small amounts of blue dye can frequently improve whiteness, even though a blue dye always decreases lightness.

In a paper presented recently to the Optical Society of America, Hunter (*9*) showed that yellowness measured by green-minus-blue reflectance should receive about four times the weight of grayness measured by loss of luminous reflectance. A simple equation for whiteness in terms of green and blue percentage reflectances is thus:

$$W = G - 4(G - B) \text{ or}$$
$$W = 4B - 3G$$

This equation rates bluish colors whiter than neutral ones, a result which seems to accord with visual practice in the evaluation of brightener whitened textiles. For an equation which rates neutrals whitest, Hunter (*9*) recommended:

$$W = 100 - \left\{\left[\frac{200(G-B)}{G + 0.242B}\right]^2 + \left(\frac{100-G}{2}\right)^2\right\}^{1/2}$$

Measurements of whiteness by the foregoing equation are most conveniently made with a graph similar to Fig. 9 on which are plotted contours of equal whiteness as functions of green and green-minus-blue reflectances.

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* TAPPI members of this Subcommittee are: Richard S. Hunter, chairman, and Robert B. Hobbs. The original report of this subcommittee is published in the *Journal of the Optical Society of America* for September, 1958 (48: 597). The present version summarizes the material previously published and then gives new data on paper products and whiteness formulas.

Recent Studies on the Polysaccharides of White Birch and Other Hardwoods

T. E. TIMELL, C. P. J. GLAUDEMANS, and J. K. GILLHAM

Recent investigations on hardwood, and especially white birchwood, polysaccharides have been reviewed. The weight-average degree of polymerization of seven native hardwood celluloses, which had been isolated by direct nitration of the wood, varied between 6000 for sugar maple (*Acer saccharum*) and 10,000 for white birch (*Betula papyrifera*). The D.P. distributions all contained only one maximum. After a determination of the general chemical composition of the woods, the structure and properties of the methyl glucuronoxylans present in white birch and white elmwood (*Ulmus Americana*) were investigated. The former hemicellulose contained an average of 197 1,4-linked β-D.P.-xylopyranose residues, with, on the average, every eleventh unit carrying a single side chain of 4-*O*-methyl-D.P.-glucuronic acid, attached by an α-glycosidic bond to C_1 of the xylose. The chain-length distribution had one maximum. The elmwood hemicellulose had a similar constitution but possessed one acid side chain for every seventh xylose residue. Its number-average D.P. was 185. The structure and molecular weight of the xylans present in yellow birch (*Betula lutea*) and sugar maple were similar, with ten xylose residues per acid group. The isolation of 4-*O*-β-D.P.-glucopyranosyl-D.P.-mannopyranose from a white birch alpha-cellulose constituted the first conclusive evidence for the presence of a chemical linkage between glucose and mannose residues in a hardwood. The isolation of 4-*O*-β-D.P.-galactopyranosyl-galactopyranose, which was a new sugar, from the same alpha-cellulose suggested the possible presence of a β-1,4-galactan. Preliminary experiments resulted in isolation of a mixture of water-soluble polysaccharides from white birchwood, yielding galactose, glucose, mannose, and arabinose on hydrolysis, together with lesser amounts of uronic acid, xylose, and rhamnose.

During the last ten years extensive research has been devoted to the polysaccharides in wood and our knowledge of this important class of polymers has been much widened. Earlier investigations in this laboratory were concerned mainly with the molecular properties of the cellulose component of various North American woods. In later years, attention has been directed toward the chemical and physical properties of the hemicelluloses. The present paper is a summary, dealing with the carbohydrates present in seven hardwoods native to eastern Canada and the United States. Since white birch (*Betula papyrifera*) has been the species most thoroughly studied until now, the cellulose, hemicelluloses, and the water-soluble polysaccharides present in this wood will form the main subject of the following discussion. Some of these investigations are still in progress and in these cases only preliminary data are available.

T. E. Timell, C. P. J. Glaudemans, and J. K. Gillham, McGill University and Pulp and Paper Research Institute of Canada, Montreal, Que.

GENERAL CHEMICAL COMPOSITION

As a preliminary to more detailed studies, the general chemical composition of a series of coniferous and deciduous woods was determined (*1*). The results obtained for the seven hardwoods are summarized in Table I. Holocelluloses were isolated by the standard TAPPI method (*2*) and exhaustively extracted with 17.5% NaOH or 24% KOH, thus yielding the corresponding alpha-celluloses. A portion of the latter was hydrolyzed and the sugar content of the hydrolyzate was determined by the *o*-aminodiphenyl method (*3*) after resolution of the mixture on paper chromatograms. All alpha-celluloses contained minor quantities of nonglucose sugar residues, namely, galactose, mannose, arabinose, and xylose. When corrections were applied for these, values were obtained which were considered representative of the "true" cellulose content of each wood. Lignin, acetyl, ash, and uronic anhydride were estimated by standard TAPPI methods. A portion of each wood was hydrolyzed (*4*) and the sugars obtained were separated by paper chromatography, eluted from the paper and quantitatively determined. All hydrolyzates contained an aldo-

Table I. Chemical Composition of Seven Species of Hardwood

All values in per cent of extractive-free wood

Species	Alpha-cellulose	Cellulose	Lignin	Acetyl	Ash	Uronic anhydride	Galactan	Glucan	Mannan	Araban	Xylan
Trembling aspen (*Populus tremuloides*)	56.5	53.3	16.3	3.4	0.2	3.3	0.8	57.3	2.3	0.4	16.0
Beech (*Fagus grandifolia*)	45.2	42.1	22.1	3.9	0.4	4.8	1.2	47.5	2.1	0.5	17.5
White birch (*Betula papyrifera*)	44.5	41.0	18.9	4.4	0.2	4.6	0.6	44.7	1.5	0.5	24.6
Yellow birch (*Betula lutea*)	43.2	40.6	21.3	3.3	0.3	4.2	0.9	46.7	3.6	0.6	20.1
White elm (*Ulmus americana*)	53.2	49.3	23.6	3.9	0.3	3.6	0.9	53.2	2.4	0.6	11.5
Red maple (*Acer rubrum*)	44.8	44.1	24.0	3.8	0.2	3.5	0.6	46.6	2.4	0.5	17.3
Sugar maple (*Acer saccharum*)	...	...	22.7	2.9	0.3	4.4	Trace	51.7	2.3	0.8	14.8

biouronic acid composed of a methyl glucuronic acid and xylose, which escaped analysis. The values obtained for the xylan content of the woods were therefore throughout somewhat too low.

The cellulose contents of the woods varied considerably, from 40% for yellow birch (*Betula lutea*) to 53% for trembling aspen (*Populus tremuloides*). The normal cellulose content of most hardwoods appears to be 41 to 44% although it should be noticed that these figures depend very much on the relative content of tension wood present as the latter usually contains much more cellulose (and also galactan) than normal wood (*5*).

It was shown in a separate investigation (*6*) that formyl groups are probably absent in wood and that a modification of the transesterification method of Whistler and Jeanes (*7*) allows an accurate estimation of the acetyl content of any wood. The acetyl groups are now considered to be mainly, if not exclusively, associated with the methyl glucuronoxylan forming the main hemicellulose constituent of all hardwoods. This hemicellulose is normally isolated by extraction with alkali, a treatment which, naturally, removes all ester groups present. Delignification with either chlorine and alcoholic ethanolamine (*8*) or with acid chlorite (*9*) leaves the acetyl groups intact (*10, 11*). If the holocelluloses thus obtained are treated with dimethyl sulphoxide, subsequent extraction with hot water yields a hemicellulose containing acetyl groups (*10*).

The uronic acids present in wood are derived partly from the methyl glucuronoxylan, partly from the pectic polygalacturonan known from the extensive studies of Anderson (*12, 13*) to be present in all woods, and in larger quantities in hardwoods than in softwoods.

It is evident from the data in Table I that the content of glucan in all the hardwoods investigated was larger than the content of cellulose. While some of this difference might be accounted for by the presence of a glucomannan di-heteropolymer, other factors must contribute to this discrepancy and the additive effect of minor analytical errors cannot be entirely excluded. Little or nothing is presently known concerning the nature of the galactose, mannose, and arabinose residues in hardwoods. Recent evidence, to be discussed later, has indicated the presence in birchwood of a galactan and a glucomannan polysaccharide (*14*). The xylan hemicelluloses isolated from hardwoods usually contain little or no arabinose residues in contrast to the corresponding polysaccharides in softwoods.

The anhydroxylose units in hardwoods seem to be derived exclusively from the methyl glucuronoxylan. The relative amount present varies considerably from one species to another. White birchwood has an exceptionally high content of xylan, 24.6%, being similar in this respect to Finnish birch (*Betula verrucosa*) (*15*). Yellow birch, on the other hand, contains less xylan, albeit somewhat more than beech, elm, and maple. The wood of white elm exhibits a xylan content only slightly higher than that of many softwoods (*1*). It is notable, however, that its content of uronic anhydride is not much lower than that of the other species.

WHITE BIRCH

White birch, sometimes referred to as paper birch or canoe birch, is a medium-sized tree ranging from coast to coast throughout the northern part of the continent. It is characterized by its white, strong, papery bark, which peels easily into strips. At present, the industrial importance of white birchwood is somewhat restricted, although a good paper pulp can be made from it. This species was selected as a typical hardwood, being more similar in chemical properties to other deciduous woods than, for example, aspen.

Approximately 30 years ago an apparent deterioration became noticeable among stands of both white birch and its near relative, the yellow birch, in certain sections of central New Brunswick (*16*). The disease, which has become known as *birch dieback*, has since spread over the entire eastern part of this continent, so that at present hardly any stands remain unaffected within this area. The first effect to be noticed is usually the presence of curled, chlorotic leaves and a generally unhealthy appearance of the tree. Later, the foliage gradually disappears and smaller twigs are eliminated. At this stage recovery is sometimes still possible but the tree is now very susceptible to attack by the birch bronze borer. In the case of such an attack, larger branches soon begin to die and after a while only the dead trunk of the tree remains. The entire cycle is usually 5 years, but trees growing under unfavorable conditions are more rapidly destroyed than specimens growing on well-drained soil.

The cause of birch dieback still remains unknown in spite of considerable efforts to elucidate it. The fact that the dieback seems to have spread from one central point would, of course, indicate an infectious disease. No strongly pathogenic fungus has, however, hitherto been isolated from affected trees. Actually, a quite general decline in the vigor of both coniferous and deciduous woods appears to have occurred in all the areas exhibiting birch dieback and it might be that birch is particularly sensitive to slight changes in climatic conditions.

In a preliminary study (*17*), four different specimens of white birch were selected, suffering from various stages of birch dieback, from a perfectly healthy tree (I) to one which had lost all its branches (IV). The contents of alpha-cellulose, lignin, pentosan, uronic

Table II. Data for Sapwood from Four Birch Trees
I: healthy tree, II, III, and IV: attacked by birch dieback

Tree	Alpha-cellulose, %	Lignin, %	Pentosan, %	Uronic anhydride, %	1% NaOH soluble, %	D.P. of cellulose
I	44.8	19.4	23.9	4.63	14.9	5450
II	45.8	18.1	24.7	4.97	18.1	5200
III	42.8	19.7	27.6	4.75	16.6	5300
IV	45.4	20.9	24.9	4.59	18.4	5350

anhydride, and alkali-solubles as well as the degree of polymerization of the cellulose were determined. Some of the data, obtained for the sapwood portion, are presented in Table II. It is evident that the dieback caused little change in the chemical or physical properties of the wood components. A comparison between the sapwood and heartwood portions indicated a slight deterioration of the latter. Over the period of decadence studied here no change evidently occurred in the chemical composition of the birchwood. In the following studies trees were therefore used which had both central Ontario and southern Quebec as their provenance, the latter an area now widely affected by birch dieback.

THE CELLULOSE COMPONENT

Isolation

Attempts to determine the molecular weight of native wood celluloses were long hampered by a lack of suitable methods for isolating the polysaccharide in an unchanged state. Early approaches, which have been summarized elsewhere (*18*, *19*) included bisulphite cooking, treatment with oxidizing agents, extraction with cuprammonium, and nitration of the wood. While mild bisulphite cooking has been used with some success, a better method is probably to nitrate the wood directly with a nondegrading acid mixture, originally developed by Staudinger and Mohr (*20*). It was found in the course of the present investigation that every wood species required its own nitration conditions. The method finally adopted was the following.

Extractive-free wood meal was treated for various lengths of time at +17°C. with a nitration mixture containing nitric acid, phosphoric acid, and phosphorus pentoxide (*21*). The nitrated wood was removed from the spent acid mixture and part of the nitrated lignin was extracted with methanol. The material was dissolved in acetone, undissolved lignin and xylan nitrate were removed on the centrifuge and the cellulose nitrate was precipitated into water. The mannan (or glucomannan) nitrate does not precipitate but a minor portion is usually occluded on the cellulose nitrate. During the nitration the lignin in the wood is nitrated, oxidized, and degraded so that most of it becomes soluble in methanol. The nitration mixture used here exerts a considerable swelling action on the wood. Attempts to use nonswelling nitration media have given unsatisfactory results (*22*, *23*), thus emphasizing the importance of swelling in making all parts of the woods accessible to the nitrating agent.

Table III. Nitration of Birchwood at +17°C.

Time, hr.	Yield,[a] %	Nitrogen, %	$[\eta]^b$	$\bar{P}_{w,w}$
1/2	7.0	13.51	25.5	2790
1	34.1	13.54	35.4	5100
2	42.7	13.65	39.0	5930
5	42.4	13.71	40.2	6100
10	41.8	13.72	38.3	5360
15	41.8	13.68	32.8	3840
20	42.3	13.65	31.2	3500
30	41.4	13.70	29.5	3040
40	41.1	13.69	25.5	2490
60	39.3	13.70	16.4	1590

[a] Calculated as cellulose in extractive-free wood.
[b] dl./g. in acetone, uncorrected for nitrate substitution.

Table IV. Nitration Characteristics of Twelve Species of Wood

Species	Time in hr. required to give maximum: Yield	Time in hr. required to give maximum: $[\eta]$	Maximum time for stability in nitration mixture, hr.
Trembling aspen	1	1	5
Beech	5	2	10
White birch	2	1	10
Yellow birch	2	2	10
White elm	2	2	10
Red maple	5	2	10
Balsam fir	48	6	100
Eastern white cedar	72	10	96
Eastern hemlock	<120	40	>120
Jack pine	40	10	72
White spruce	25	15	20
Tamarack	40	10	96

The time required for complete removal of the cellulose from the wood in the form of the nitrate and the stability of the latter in the nitrating mixture were found to vary appreciably from one species to another. Hardwoods were always more rapidly nitrated than softwoods. A typical example, pertaining to white birchwood, is presented in Table III. Maximum yield was attained after only 2 hr. and after this time maximum intrinsic viscosity was also noticed. After 5 hr. depolymerization became evident. In this connection it could be shown that the presence of soluble degradation products from the lignin in the nitration

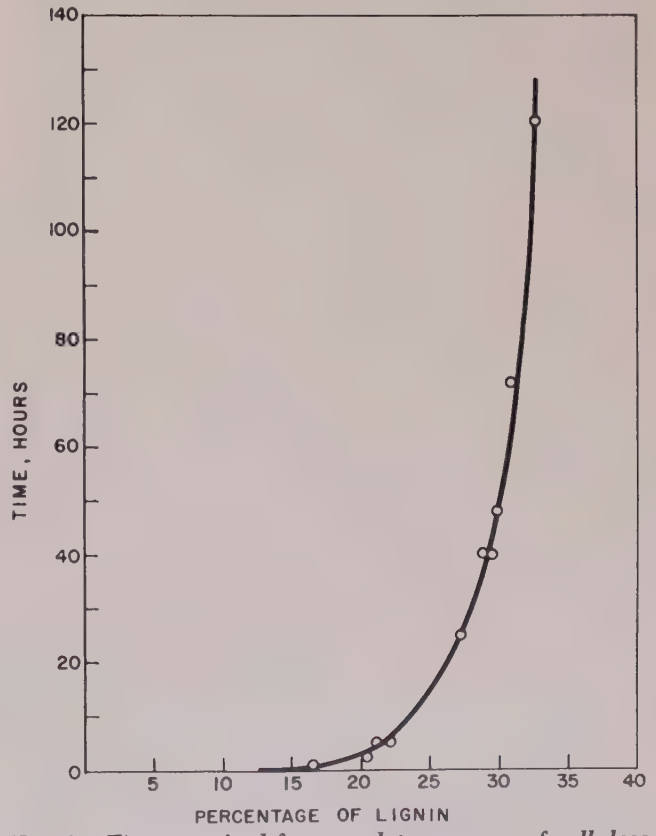


Fig. 1. Time required for complete recovery of cellulose nitrate versus lignin content of each wood

Table V. Weight-weight Average Degrees of Polymerization of Some Celluloses from White Birchwood

Source	$\bar{P}_{w,w}$
Heartwood	5000
Sapwood	5600
Total wood	5500
Chlorine holocellulose	4700
Chlorite holocellulose	3300
Alpha-cellulose	2500

mixture greatly enhanced the stability of the cellulose nitrate. A summary of data obtained with some of the woods investigated is given in Table IV. The time required for a complete recovery of the wood cellulose was 1 to 5 hr. for the hardwoods and 25 to 120 hr. for the softwoods. The latter were, however, considerably more stable in the nitration mixture than the former.

There appeared to exist a relationship between the lignin content of the woods and the time necessary for complete nitration, the latter increasing rapidly with increasing lignin content, as is seen in Fig. 1. The general difference in nitration behavior between hardwoods and softwoods might, however, be related not only to the lower lignin content of the former, but also to the morphological differences between the two kinds of wood. Most of the lignin in hardwoods appears to be located in the middle lamella (*24*) whereas the secondary wall of the softwood tracheids is much more heavily lignified. It does not seem unreasonable to assume that the cellulose in the softwoods is less accessible to the nitrating mixture due to this difference. That penetration and diffusion can vary enormously from one species to another has recently been clearly demonstrated by Stone (*25*).

Sometimes it is desirable to isolate not only the cellulose but also the holocellulose component of a wood in an unchanged state. This is the case, for example, in studies of softwood hemicelluloses which cannot be isolated without prior delignification. When birchwood was treated with chlorine in ice-water and subsequently extracted with alcoholic ethanolamine, the cellulose portion of the resulting holocellulose had suffered little depolymerization (*26*). Treatment with acid chlorite (*9*), on the other hand, gave a severely degraded product and the same applied to an alpha-cellulose obtained by alkaline extraction of the chlorine holocellulose (Table V). Losses of sugars also occurred at an earlier stage of delignification when the chlorite method was used. Apparently the lignin protects the carbohydrates in the cell wall from the hydrolytic action of the aqueous chlorine. As soon as the last lignin has been removed, depolymerization becomes evident. In the treatment with the hot, acid chlorite, the oxidized lignin gradually dissolves in the water, thus leaving the cellulose unprotected.

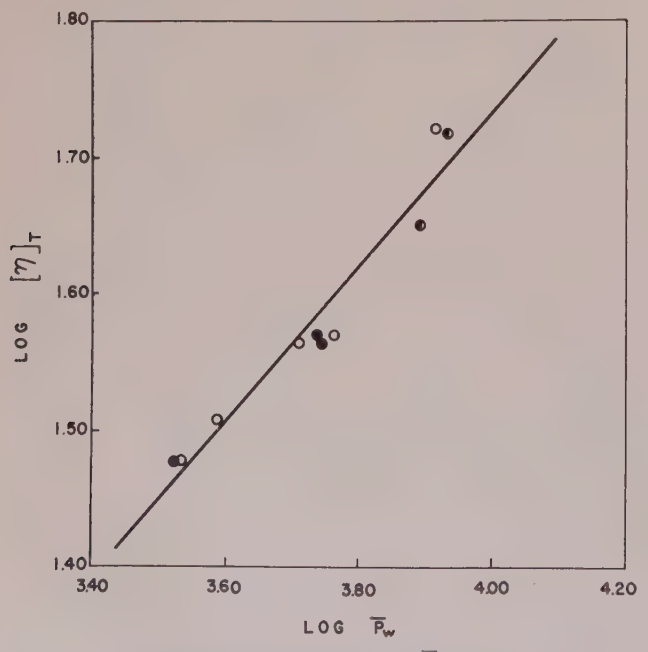


Fig. 2. Relationship between $[\eta]_T$ and $\bar{P}_W$ as obtained from viscometry and light-scattering data
○ Acetone solution. ● Ethyl acetate solution.

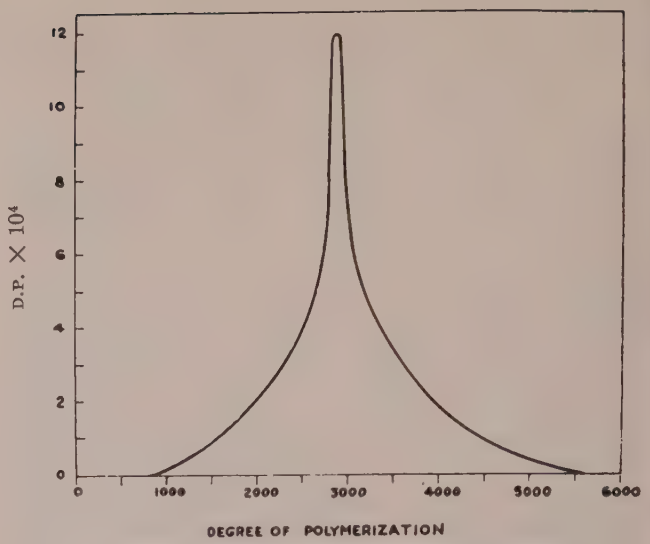


Fig. 3. Frequency weight distribution for nitrated birchwood cellulose

Molecular Weight

In the earlier investigations the intrinsic viscosity of the nitrated wood celluloses was determined in ethyl acetate at a constant rate of shear of 500 sec.$^{-1}$ (*18*, *27*, *28*, *29*). After corrections had been applied for variations in nitrogen substitution according to Lindsley and Frank (*30*), $[\eta]_{500}$ (dl. per g.) was related to the weight-weight average molecular weight according to the relationship developed by Newman, Loeb, and Conrad (*31*) from sedimentation-diffusion measurements:

$$[\eta]_{500} = 4.82\ 10^{-5}\ \bar{M}_w^{0.99}$$

Some of the data thus obtained for white birch celluloses are given in Table V. Apparently sapwood cellulose had a higher molecular weight than that present in the heartwood.

In recent years several attempts have been made to correlate the intrinsic viscosity of cellulose nitrates with their weight-average molecular weights as determined from light-scattering measurements. Such relationships have been developed by Holtzer, Benoit, and Doty (*32*), by Hunt, Newman, Scheraga, and Flory (*33*), and, most recently, by Huque, Goring, and Mason (*34*). The latter workers used a series of cellulose nitrates ranging in molecular weight from 0.65 10^6 to 2.5 10^6. These samples were kindly made available for the present study (*35*). Their intrinsic viscosity was determined in *n*-butyl acetate in a Craig-

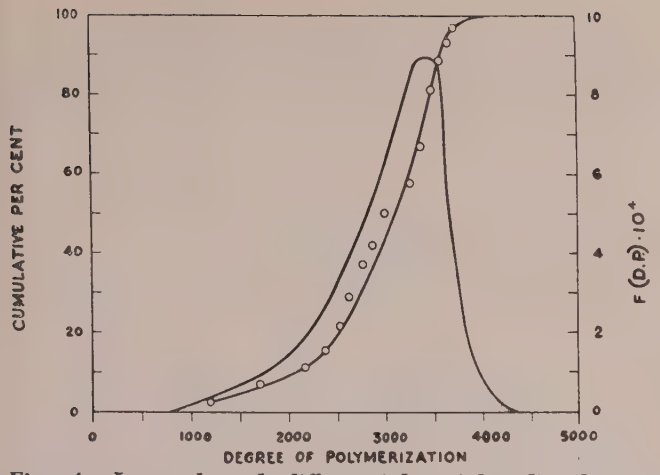


Fig. 4. Integral and differential weight distribution curves for nitrated birch holocellulose

Henderson viscometer (*36*) at an approximate shear rate of 1000 sec.$^{-1}$ and recalculated to be valid at a theoretical trisubstitution ($[\eta]_T$). The relationship between log $[\eta]_T$ and log $\bar{P}_w$ as determined by light-scattering measurements in ethyl acetate and acetone is given in Fig. 2; the corresponding equation was

$$[\eta]_T = 0.278\ \bar{P}_w^{0.572}$$

The value of the exponent would indicate a solvent-impermeable Gaussian coil, but probably little significance should be attributed to this value as the rate of shear was not kept constant during the measurements.

Cellulosic materials from 22 different sources were nitrated as described above under conditions known to ensure a maximum yield of cellulose with a minimum of degradation for each particular species. Data obtained for the hardwoods are summarized in Table VI. With one exception, the yield on nitration and the cellulose content of the woods agreed reasonably, thus indicating that all cellulose in the wood had been accounted for. The weight-average degrees of polymerization ranged from 6000 for the sugar maple to 9000 for the white birch cellulose. Other experiments with other specimens of the latter wood indicated a $\bar{P}_w$ of approximately 10,000. This was a value similar to those found by the same methods for celluloses from seed hairs such as cotton or kapok (*35*) and bast fibers, such as hemp (*37*). A series of softwood celluloses exhibited degrees of polymerization in a range of 6000 to 9000 (*35*). A part of the discrepancy between the earlier $\bar{P}_{w,w}$ and the later $\bar{P}_w$ values was undoubtedly due to the fact that only the latter were true weight-average values and could be expected to be higher than the former (*38*).

Table VI. Nitration and Determination of $\bar{P}_w$

Species	*Cellulose, %*	*Nitration[a] yield, %*	$[\eta]_T$[b]	$\bar{P}_w$[c]
Trembling aspen	53	54.7	47.8	8050
Beech	42	37.6	46.2	7600
White birch	41	42.4	50.8	9000
Yellow birch	40	40.2	49.7	8700
White elm	49	39.7	42.2	6500
Red maple	44	44.2	45.5	7450
Sugar maple	..	43.6	40.0	6000

[a] Calculated as cellulose.
[b] dl./g. in *n*-butyl acetate at trisubstitution.
[c] Weight-average degree of polymerization.

Molecular-Weight Distribution

The molecular-weight distribution of the cellulose nitrates was determined by a two-stage fractional precipitation procedure employing acetone-water as the solvent-nonsolvent system (*29*, *39*). Each fraction was analyzed for intrinsic viscosity and nitrate substitution and the integral and differential (frequency) distribution curves were constructed in the usual way. The frequency distribution curve of the birchwood cellulose is presented in Fig. 3, with degrees of polymerization given as $\bar{P}_{w,w}$ values. Some degradation always occurred during the fractionation and the D.P. limits are therefore of little significance. The corresponding distribution of a cellulose obtained via a chlorine holocellulose is seen in Fig. 4. Apparently a preferential depolymerization of the long-chain material had taken place. This tendency is even more pronounced in the case of the corresponding alpha-cellulose (Fig. 5).

The other hardwood celluloses had similar chain-length distributions, aspen cellulose being typical (Fig. 6). Similar molecular-weight distributions were obtained for celluloses from several bast fibers such as jute, hemp (*40*), and ramie (*39*). Softwood celluloses, on the other hand, were found to contain two maxima (*27*, *29*), although the significance of the first peak remained extremely doubtful (*28*).

THE MAIN HEMICELLULOSE COMPONENT

Isolation

The main hemicellulose constituent in white birchwood, as in all hardwoods, is a xylan polysaccharide. For its isolation various methods are available. One involves a direct extraction of the wood with aqueous alkali in an atmosphere of nitrogen. Except for the elimination of acetyl groups, this procedure probably involves only slight changes in the properties of the polymer. However, only 80 to 90% of the hemicellulose can be obtained in this way, the remainder probably being protected by the amorphous lignin or the fibrillar cellulose, especially in the sections of the secondary wall adjacent to the lumen (*41*). Delignification of the wood by either of the two standard methods followed by extraction with alkali make a quantitative recovery possible.

In an attempt to establish the possible effect of the delignifying agents on the hemicellulose, one chlorine

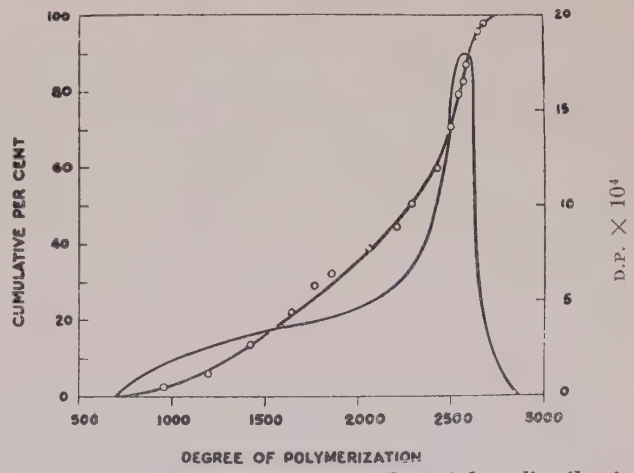


Fig. 5. Integral and differential weight distribution curves for nitrated birch alpha-cellulose

Table VII. Isolation and Molecular Properties of Hemicelluloses

Source	Yield, %	[η]	$\bar{M}_n$	$\bar{P}_n$
Original wood	19.4	0.88	46,200	195
Chlorine holocellulose	27.1	0.90	46,800	198
Chlorite holocellulose I	29.8	0.67	29,200	123
Chlorite holocellulose II	29.9	0.64	28,300	119
Chlorite holocellulose III	28.1	0.63	...	...
Chlorite holocellulose IV	26.1	0.59	28,100	118

and four chlorite holocelluloses were prepared from white birchwood (*42*). The chlorine holocellulose was obtained by the method of Timell and Jahn (*26*) and the corresponding chlorite products by treating the wood with acid chlorite for 6, 7, 8, and 9 hr., respectively, as described by Wise, Murphy, and D'Addieco (*9*). The original, untreated wood as well as the five holocelluloses were extracted with 24% KOH. The intrinsic viscosity of the hemicelluloses thus obtained was determined in cupriethylenediamine and the number-average molecular weight of the acetate derivatives was obtained from osmotic pressure measurements. Some of the values are summarized in Table VII. It is evident that the chlorine had no depolymerizing effect on the hemicellulose, whereas the acid chlorite degraded the polysaccharide more the longer the treatment. Not only the molecular weight but also the chemical properties of the hemicelluloses isolated directly from the wood and from the chlorine holocellulose were identical. Both methods were accordingly used for preparing additional amounts of hemicelluloses for structural and molecular-weight studies. Similar observations were subsequently made with white elmwood. Because of its simplicity and relatively mild nature, direct alkaline extraction of hardwoods should be the preferred method for isolating their hemicelluloses. With softwoods, the yields are too low to make this procedure possible.

Constitution

Alkaline extraction of a chlorine holocellulose from white birchwood gave a hemicellulose in a yield of 27.1% of the extractive-free wood, corresponding closely to the known content of methyl glucuronoxylan of the wood. Hydrolysis of the hemicellulose yielded a mixture of sugars containing mainly uronic acids and xylose. The former were separated from the xylose on a column of anion exchange resin and the mixture was further resolved into three components by cellulose or filter paper chromatography (*43*). In subsequent studies, larger quantities of uronic acids were more easily obtained by adding the mixture of acids to the top of a column of Dowex 1-X4 (acetate form) exchange resin and eluting the *N* acetic acid (*44*). In a typical case an aldotriouronic acid, an aldobiouronic acid, a hexuronic acid, and a methyl hexuronic acid could be eluted in this order. Another convenient method involved the use of a cocoanut charcoal column (*45*). Elution with 4% aqueous ethanol removed the tri and monouronic acids in a relatively pure state and subsequent elution with 15% ethanol furnished a pure aldobiouronic acid. As much as 50 g. of uronic acids could be resolved on a medium-sized (5 by 30 cm.) column of this absorbant.

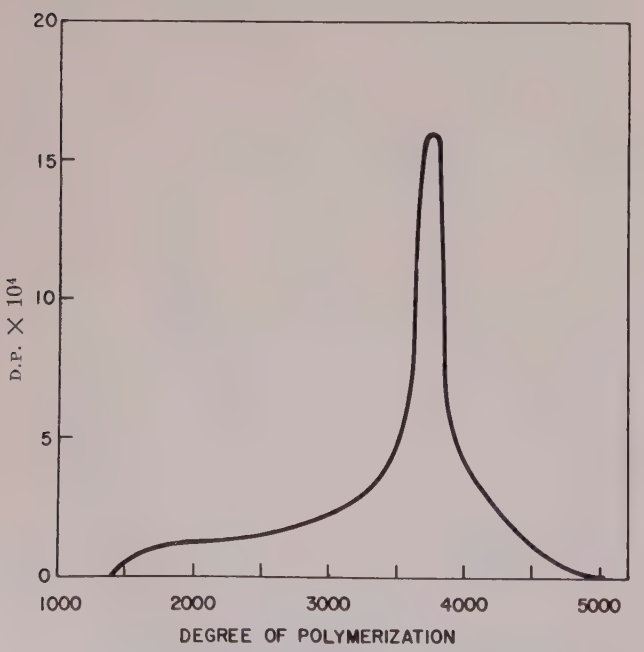


Fig. 6. Frequency weight distribution for nitrated aspen cellulose

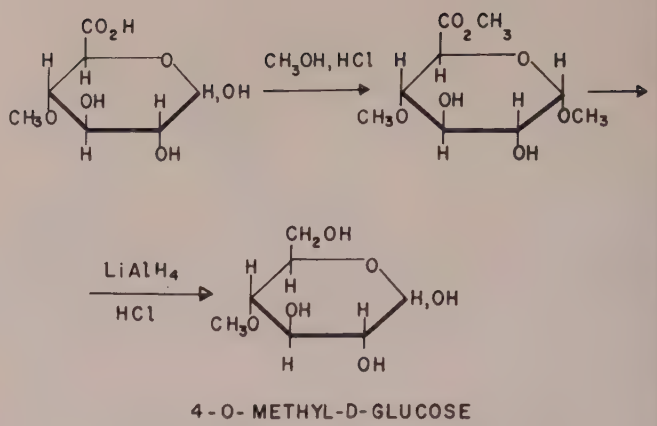


Fig. 7. Characterization of 4-O-methyl-D-glucuronic acid

Of the three acids obtained from white birchwood, a hexuronic acid was present in only minor quantity. It could be reduced to galactose and was thus galacturonic acid. This constituent was considered to arise from occluded pectic material.

A mono-*o*-methyl monouronic acid (Fig. 7) was converted to the ester-glycoside and reduced with lithium aluminum hydride to yield 4-*O*-methyl-D-glucose, thus proving that the acid was 4-*O*-methyl-D-glucuronic acid, a very common constituent of wood hemicelluloses.

The third acid ($[\alpha]_D^{20}$ + 108° in water), which was the major component of the mixture, was a mono-*O*-methyl aldobiouronic acid. Reduction of the ester-glycoside followed by hydrolysis gave D-xylose and 4-*O*-methyl-D-glucose. The completely methylated product (Fig. 8), when reduced and hydrolyzed, yielded 3,4-di-*O*-methyl-D-xylose and 2,3,4,-tri-*O*-methyl-D-glucose. Methylation of the reduced aldobiouronic acid followed by hydrolysis similarly gave 3,4-di-*O*-methyl-D-xylose and 2,3,4,6-tetra-*O*-methyl-D-glucose. The aldobiouronic acid was accordingly 2-*O*-(4-*O*-methyl-α-D-glucopyranosyluronic acid)-D-xylopyranose, a compound which has been identified in many plants. Oxidation with lead tetraacetate yielded formaldehyde, a result to be expected only from a 1,2-linked disaccharide, thus corroborating the above evidence.

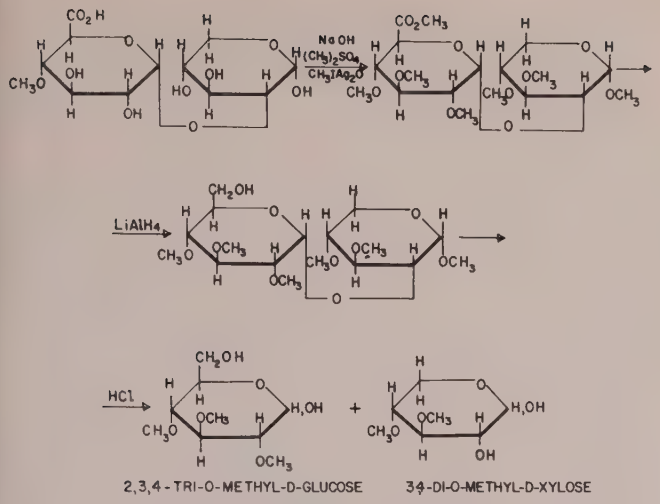
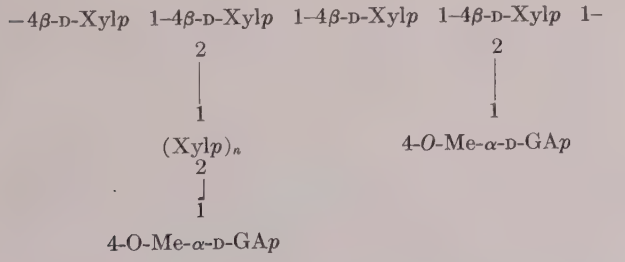


Fig. 8. Identification of 2-O-(4-O-methyl-α-D-glucopyranosyluronic acid)-D-xylopyranose

It was apparent from the high pentosan content (88%) and from the products of hydrolysis that the polysaccharide was composed of xylose building units. The isolation of two of the above acids suggested that it contained side-chains of 4-*O*-methyl-D-glucuronic acid. If this were so, the uronic anhydride and methoxyl contents corresponded to 10.8 and 10.3 anhydroxylose units per acid group, respectively. The equivalent weight of the acidic hemicellulose gave a value of 10.3 and oxidation with periodate a value of 11.4.

The hemicellulose was methylated to completion (39.2%) and subjected to methanolysis under conditions known to effect no cleavage of any aldobiouronic acid. The glucosides were quantitatively separated into an acidic and a neutral fraction on an anion exchange resin. The acid portion contained only one component. Reduction of its ester-glycoside and hydrolysis yielded 3-*O*-methyl-D-xylose and 2,3,4-tri-*O*-methyl-D-glucose (Fig. 9), and the acid was accordingly methyl 2-*O*-(2,3,4-tri-*O*-methyl-D-glucopyranosyluronic acid)-3-*O*-methyl-D-xylopyranoside. When the free acid itself was methylated, the 4-position of its xylose moiety contained a methoxyl group which was missing in the above fragment, thus indicating that the latter must have been linked to other xylose residues with the backbone of the 1,4-linked xylan. This suggested strongly that the 4-*O*-methyl-D-glucuronic acid residues were present as single side chains, attached



directly to the main polymer chain. A polysaccharide such as that depicted below, with a side chain of the type located on the left would, on methylation and subsequent hydrolysis, have given rise to 3,4-di-*O*-methyl-D-xylose. No such derivative could be found, thus

Table VIII. Sugars Obtained from the Methylated Hemicellulose

Component	*Weight, mg.*	*Molar ratio* I^a	II^b
2-*O*- and 3-*O*-methyl-D-xylose	79	2.7	3.7
2,3-di-*O*-methyl-D-xylose	3765	116	126
2,3,4-tri-*O*-methyl-D-xylose	35	1	1
Methyl 2-*O*-(2,3,4-tri-*O*-methyl-α-D-glucuronosyl)-3-*O*-methyl-D-xyloside	801	11.1	...

[a] From weight of fractions.
[b] By quantitative paper chromatography.

corroborating the above conclusion, the side chains instead being of the type depicted to the right.

The neutral glycoside fraction was hydrolyzed and the resulting mixture of reducing sugars was resolved on a carbon-Celite column by gradient elution with aqueous ethanol to give three fractions, the second of which was by far the predominating one, as is seen in Fig. 10. An alternative method of separation involved fractional extraction of the mixture of methylated xyloses with chloroform and was used with a xylan from white elmwood. Fraction I could be resolved by paper ionophoresis into two components, corresponding in rate of movements to 2-*O*- and 3-*O*-methyl-D-xylose, the latter of which was the main constituent. Fraction II was characterized as 2,3-di-*O*-methyl-D-xylose and fraction III as 2,3,4-tri-*O*-methyl-D-xylose. A minor portion of the sugar mixture was also resolved by paper chromatography and the ratio between the three methyl sugars was determined by the *o*-aminodiphenyl method. The relative amounts obtained agreed fairly well with those calculated from the actual weights of the fractions as is seen in Table VIII.

The large quantity of 2,3-di-*O*-methyl-D-xylose isolated and the high negative rotation ($[\alpha]_D^{20}$-83°) indicated that the hemicellulose was composed of a framework of 1,4-linked β-D-xylopyranose residues. The tri-*O*-methyl xylose evidently originated from the nonreducing end groups of the polysaccharide. After methylation and hydrolysis, all side groups were recovered as the partially methylated aldobiouronic acid referred to above, one mole being obtained per 11.9 moles of methylated xylose in agreement with the above data. The two mono-*O*-methyl xyloses were therefore either artifacts or represented branching points in the molecule.

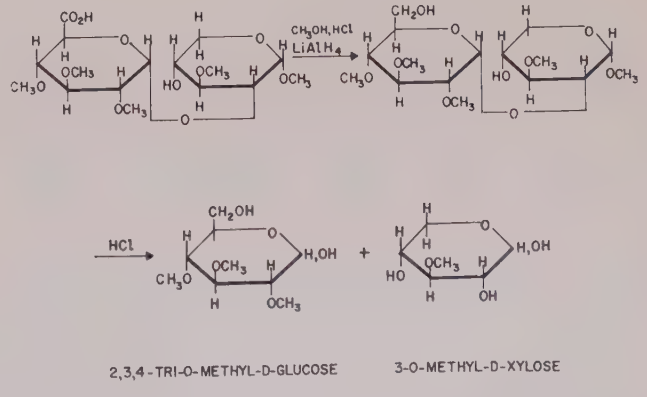


Fig. 9. Identification of methyl 2-O-(2,3,4-tri-O-methyl-α-D-glucopyranosyluronic acid)-3-O-methyl-D-xylopyranoside

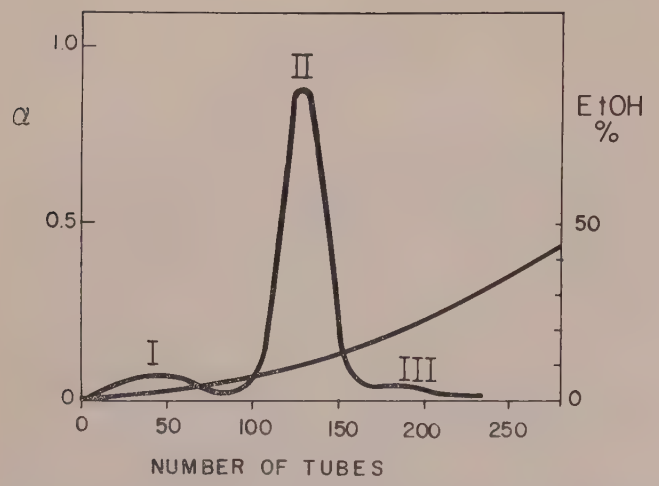


Fig. 10. Separation of methylated xyloses on a charcoal-Celite column by gradient elution with aqueous ethanol

In order to resolve this problem, the number-average molecular weight of the fully methylated polysaccharide was determined by osmometry. The value obtained was 19,800. If one 4-*O*-methyl-D-glucuronic acid residue is assumed to be associated with 11 anhydroxylose units, the weight of the repeating unit is 1978 and ten such units were therefore present per molecule, resulting in an average degree of polymerization of 110. Since the value calculated from the number of non-reducing end groups was 130, this definitely precluded the possibility of any branching of the xylan part of the polysaccharide. The mono-*O*-methyl xyloses were accordingly artifacts, probably caused by demethylation during the hydrolysis of the methylated hemicellulose.

From the above evidence a simplified structure can be assigned to the methyl glucuronoxylan present in white birchwood. This polysaccharide consists of a minimum of 110 β-D-xylopyranose residues linked together by 1,4-glycosidic bonds and with, on the average, every eleventh anhydroxylose unit carrying a single side chain of 4-*O*-methyl-D-glycuronic acid attached by an α-glycosidic linkage to the 2-position of the xylose (Fig. 11).

Molecular Properties

Earlier studies on the molecular properties of native

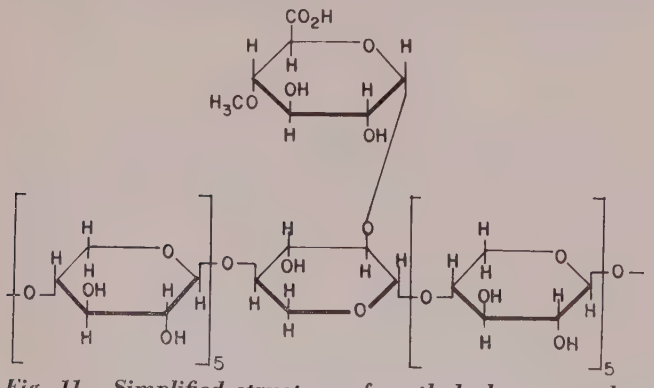


Fig. 11. Simplified structure of methyl glucuronoxylan from white birchwood

wood hemicelluloses have been summarized elsewhere (*46*). In many of these investigations the molecular weights obtained were probably too low, either because the material had been degraded during its isolation or because derivatives were used which were only partially soluble. With one exception (*47*) only number-average molecular weights have so far been determined.

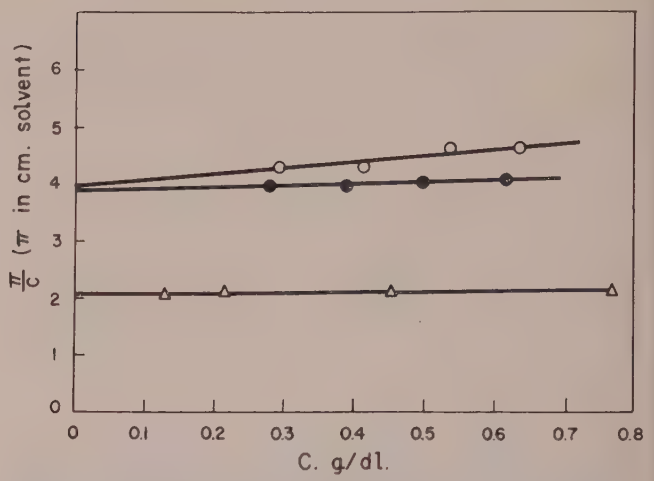


Fig 12. Reduce osmotic pressure vs. concentration of acetylated methyl glucuronoxylan in different solvents
○ Chloroform with 10% ethanol. ● Chloroform with 4% ethanol. △ Pure chloroform.

Methyl glucuronoxylans from white birch, which had been isolated by either direct alkaline extraction of the wood or via the chlorine holocellulose (*42*), were converted by the method of Carson and Maclay (*48*) to acetate and butyrate derivatives without any apparent depolymerization. The fully substituted acetates were completely soluble in chloroform or chloroform-ethanol but the two butyrate esters were only partly soluble. The molecular weight of the derivatives was determined from osmotic pressure measurements. The instrument was of the Zimm-Myerson (*49*) type as improved by Stabin and Immergut (*50*). Gel cellophane membranes which had never been allowed to dry were used, the temperature was 30°C., and the static method of measuring the osmotic rise was employed. Diffusion of polymer through the membrane was negligible. Some of the results obtained are presented in Table IX and in Fig. 12.

It is evident that the value obtained for one of the acetates in pure chloroform is too high and undoubtedly caused by molecular association. The butyrates exhibited no such phenomenon. The somewhat lower values noted in this case were presumably due to the fact that the insoluble material represented the high molecular-weight portion of the polymer. Attempts to measure the molecular weight of the hemicellulose itself in dimethyl sulphoxide failed because of the un-

Table IX. Molecular Properties of the Acrylated Hemicelluloses

A: Chloroform, B: Chloroform with 4% ethanol, C: Chloroform with 10% ethanol

Sample	*Solvent*	*Acyl, %*	$\bar{M}_n$	$\bar{P}_n$
Acetate I	A	38.2	85,400	360
Acetate I	B	38.2	46,800	198
Acetate I	C	38.2	46,300	196
Acetate II	C	37.6	46,200	195
Butyrate I	A	50.9	52,500	178
Butyrate II	C	50.3	54,800	185

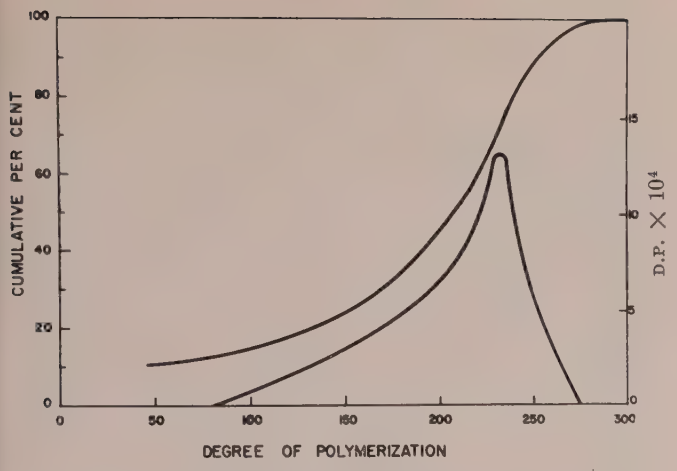


Fig. 13. Integral and differential distribution curves of the methyl glucuronoxylan

desirable properties of the solvent. Similar observations have been made elsewhere (*51*).

The number-average degree of polymerization of the native polysaccharide was 197, corresponding to a molecular weight of 29,400. These are values higher than have hitherto been reported. Under normal conditions, a *Pn* value of approximately 200 would correspond to a weight-average value of 400. The P_n value of the cellulose in white birchwood is 10,000 and there is thus an enormous difference in this respect between the hemicellulose and cellulose components.

The molecular-weight distribution of the hemicellulose was determined by fractional precipitation, either by adding ethanol or methanol to an alkaline solution of the polysaccharide or by gradual addition of hexane to a chloroform-alcohol solution of the acetate derivative. In the former case the fractions were also analyzed for specific rotation, uronic anhydride and methoxyl contents. Fractionation occurred according to both physical and chemical properties, molecules containing more acid groups remaining longer in solution. Some of these effects were presumably eliminated when the acetate was used but the fractionation curves obtained in the two cases did not exhibit any large differences. The distribution curves in Fig. 13 were obtained with the unsubstituted hemicellulose. The frequency distribution contains only one maximum and has a negative skewness. Similar results were obtained with a methyl glucuronoxylan from milkweed floss (*52*).

Comparison with Other Methyl Glucuronoxylans

Hardwood hemicelluloses presently being studied in these laboratories also include those present in white elm, yellow birch, and sugar maple. Of these, only the elm hemicellulose has so far been fully characterized. This polysaccharide (*53*) has a structure very similar to that of the hemicellulose present in white birchwood, with the exception that, on the average, every seventh anhydroxylose unit carries a single chain of 4-*O*-methyl-D-glucuronic acid. In addition to the sugar acids obtained from birchwood, the elm hemicellulose also yielded a triouronic acid composed of the aldobiouronic acid and xylose and small amounts of a glucuronosyl xylose containing no methoxy group. The hemicelluloses present in yellow birch and sugar maple (*11*) are both composed of β-D-xylopyranose residues, joined by 1,4-linkages and with every tenth xylose containing a side chain of 4-*O*-methyl-D-glucuronic acid.

The basic framework of β-1,4-linked xylopyranose residues is typical of almost all plant xylans (*54*). While many of these, for example those in corn cob (*55*), esparto grass (*56*), and wheat straw (*55, 57, 58*), are branched, all wood xylans so far studied, with only one possible exception (*59*), appear to be linear. Most xylans contain side chains attached directly to the backbone of the macromolecule, usually a 1,2-linked 4-*O*-methyl-D-glucuronic acid, a 1,3-linked D-glucuronic acid or a 1,3-linked L-arabofuranose residue. Every wood xylan so far investigated has been found to contain the first type of substituent and in the case of Monterey pine (*Pinus radiata*) a 1,3-linked 4-*O*-methyl-D-glucuronic acid has also been detected, albeit in minute quantities (*60*). Softwood xylans contain fairly large amounts of terminal L-arabofuranose residues. These are usually absent in hardwood xylans or present in only small quantities. Extraction of trembling aspenwood (*Populus tremuloides*) with alkali has recently yielded a xylan containing end groups of L-arabofuranose residues (*61, cf. 62*).

The relative amounts of acid groups vary from one species to another as is seen in Table X, from only four xylose residues per acid group for a xylan from western hemlock to a value of 14 for a xylan from milkweed floss. Although it should be noted that a quantitative recovery of a pure xylan from a softwood has never been achieved, it is clear that these hemicelluloses, in addition to their L-arabofuranose side chains, also contain more acid side groups than do most of the hardwoods. The hemicellulose in white elmwood is apparently an exception in this respect, containing as many 4-*O*-methyl-D-glucuronic acid groups as a xylan from loblolly pine. As was pointed out above, elmwood is similar to softwoods also in its relatively low content of xylan. Judging from the limited number of species so far studied, it appears as if a low content of xylan in a wood is usually associated with a larger number of acid side groups in the xylan. The problem of the nature and the relative amount of side chains in xylan hemicelluloses is of importance because these groups determine to a large extent the properties of these polysaccharides and thus also their behavior in technical processes.

Table X. Number of Xylose Residues per 4-*O*-Methyl-D-glucuronic Acid Side Group in Some Hemicelluloses

Source	*Xylose/uronic acid*
Western hemlock (*85*)	4
Norway spruce (*86, 87*)	5
European larch (*88*)	5–6
Loblolly pine (*75*)	6–7
White elm (*53*)	7
Kapok (*89*)	7
Flax (*90*)	8
Trembling aspen (*61*), beech (*63*), white birch (*43*), yellow birch, sugar maple (*11*)	10–11
Milkweed floss (*52*)	14

Of the hardwood xylans so far studied, namely, those present in American beech (*Fagus grandifolia*) (*59*),

European beech (*Fagus sylvatica*) (*63*), Finnish birch (*Betula verrucosa*) (*64*), and trembling aspen (*61, 62*), the four hemicelluloses dealt with here resemble most closely the polysaccharide present in European beech. Other hardwoods probably contain similar polysaccharides although it should be emphasized that several problems remain unsolved. The exact location of the acetyl groups in native xylans is not known, nor is the nature of the uronic acid groups in the wood clear. Studies of Nelson and Schuerch (*41*) with white birchwood have indicated the absence of any chemical linkage between cellulose and hemicellulose in this species. The possibilities of such linkages are, on the other hand, strongly suggested by recent results obtained by Lindgren (*65*) with a "lignin-carbohydrate complex" from a Björkman lignin.

The molecular properties of wood hemicelluloses have been less investigated than their chemical properties. The methyl glucuronoxylans present in white elm (*53*), yellow birch, and sugar maple (*11*) have number-average degrees of polymerization of the same order of magnitude as that in white birch. It is unfortunate that no reliable data are presently available as to the weight-average molecular weight of any native xylan.

POLYSACCHARIDES ASSOCIATED WITH THE ALPHA-CELLULOSE

In connection with the determination of the methyl glucuronoxylan in white birchwood, an attempt was also made to prepare a cellulose from the same species containing only β-D-glucopyranose residues (*14*). Although the wood was exhaustively extracted with alcohol-benzene and subsequently delignified with chlorine-ethanolamine, followed by exhaustive extraction with alkali, the preparations obtained invariably contained nonglucose residues. An alpha-cellulose was prepared containing 4% mannose and 4% xylose residues in addition to minor quantities of galactose, arabinose, and rhamnose. When this product was subjected to partial hydrolysis, a series of oligosaccharides was obtained. The structure of these sugars was determined in an attempt to determine whether or not chemical linkages existed between glucose and nonglucose residues. The absence of any reversion products was established in a separate experiment. Resolution of the sugar mixture by paper chromatography in an acid solvent indicated the presence of nine different oligosaccharides, six of which were obtained pure after further resolution with basic solvent system.

Two of the oligosaccharides were present in small amounts and could be only tentatively characterized as a glucosyl mannose and a galactosyl mannose (or a galactosyl glucose), respectively. The fastest moving component on the chromatogram crystallized and was characterized as 4-*O*-β-D-xylopyranosyl-D-xylopyranose (xylobiose).

The remaining three sugars were all disaccharides. Two were identified through their crystalline acetaacetates as 4-*O*-β-D-glucopyranosyl-D-glucopyranose (cellobiose) and 4-*O*-β-D-glucopyranosyl-D-mannopyranose. The third disaccharide, which gave only galactose on hydrolysis, crystallized but its properties (m.p. + 204°C., $[\alpha]_D^{20}$ + 68° in water) did not agree with those of any known galactobiose. A structural investigation, carried out by A. S. Perlin (*66*) indicated that the disaccharide was 4-*O*-β-D-galactopyranosyl-D-galactopyranose, only the α-anomer of which has hitherto been known (*67*).

The origin of the above disaccharides can be only tentatively suggested. The general problem whether wood celluloses contain only glucose residues has been much discussed in recent years. Earlier results were generally interpreted to indicate the presence of non-glucose sugars within the framework of the cellulose. Recent evidence, however, has tended to favor an opposite view (*28, 68, 69*). In at least two cases (*70, 71*) alpha-celluloses containing less than 1% of nonglucose residues have been prepared from wood. The difficulties experienced in removing the last traces of especially glucomannan but also xylan from alpha-celluloses is probably due to the strong adsorptive forces holding these hemicelluloses to the cellulose microfibrils. The considerable strength of these forces has recently been clearly demonstrated by Yllner and Enström (*72*).

The cellobiose undoubtedly originated from the cellulose component of the alpha-cellulose while the xylobiose was derived from occluded methyl glucuronoxylan. The origin of the other two disaccharides is less clear. A glucosyl mannose identical to the present one has previously been isolated from slash pine (*Pinus caribaea*) alpha-cellulose (*73, 74*) and also from glucomannans present in many softwoods, such as loblolly pine (*Pinus taèda*) (*75*), white spruce (*Picea glauca*) (*76*), and a Mitscherlich spruce pulp (*77*). While it appears probable that all softwoods contain most of their mannose residues in the form of glucomannan diheteropolymers, little is presently known about the small amounts of anhydromannose units present in hardwoods. Methylation data obtained in a study of the hemicelluloses in trembling aspen (*61*) suggest the existence of a β-1,4-linked glucomannan in this species. The isolation of the above β-1,4-glucosyl mannose constitutes the first definite evidence for the presence of a chemical linkage between glucose and mannose in a hardwood.

The origin of the β-1,4-galactobiose is even more uncertain. Many of the galactose residues in softwoods are apparently derived from water-soluble arabogalactans, the structure of which have been determined for a few species, such as European larch (*Larix decidua*) (*78*), Jeffrey pine (*Pinus Jeffreyi*) (*79*), jack pine (*Pinus Banksiana*) (*80*), and white spruce (*81*). In all these cases the polysaccharide contained a highly branched framework of 1,3- and 1,6-linked galactose residues. At present, no information is available as to the presence of a similar polysaccharide in hardwoods. As was mentioned above, small amounts of pectin have been located in many woods, yielding D-galacturonic acid on hydrolysis. The same sugar has been obtained in fairly large quantities from white birchwood (*11*). In most pectic materials, the polygalacturonic acid is associated with galactan and araban which are extremely difficult to remove from the polyuronide. The structure of a pectic galactan has been established in only one case, namely, for a product isolated from *Lupinus albus* seeds (*82*). This was found to contain approximately 100 β-D-galactopyranose residues linked together by 1,4-glycosidic bonds. The isolation of the above β-1,4-galactobiose might be

interpreted to suggest the presence of a similar polysaccharide in white birchwood.

While the present results constitute no positive evidence for the presence of a true cellulose in white birchwood, the absence of any disaccharide containing both glucose and xylose residues is probably significant. This, together with the fact that the glucosyl mannose presumably originated from a glucomannan, suggests that no chemical linkages exist between the cellulose and the hemicellulose portions of this wood. The presence in white birchwood of a framework of cellulose, consisting exclusively of 1,4-linked β-D-glucopyranose residues, therefore, appears, if not unequivocally established, at least highly probable.

WATER-SOLUBLE POLYSACCHARIDES

Little information is presently available concerning the nature of the water-soluble polysaccharides of hardwoods. The yields obtained on extraction with water are much lower than those noted for softwoods, many of which, and especially the larches, contain appreciable quantities of water-soluble arabogalactans. Extraction with water of white sprucewood has recently, in addition to an arabogalactan, also yielded a polysaccharide which might be a galactoglucomannan (*81*).

Quick (*83*), extracting trembling aspenwood with cold water, obtained a polysaccharide mixture which on hydrolysis yielded galactose, glucose, mannose, arabinose, xylose, fucose, and rhamnose. Investigations on the water-soluble polysaccharides in white birchwood have recently been undertaken in the present laboratories (*84*). Extraction of 60 to 80 mesh wood meal with water at 25°C. gave a white polysaccharide in a yield of 0.1% by weight of the extractive-free wood. Its specific rotation was low and on hydrolysis it yielded galacturonic (or glucuronic) acid, galactose, glucose, mannose, arabinose, and xylose in an approximate ratio of 1:5:4:3:3:2, together with a minor quantity of rhamnose. Extraction with water, buffered with potassium acetate, at 70°C. gave another polysaccharide material in a yield of 0.9%. The yields obtained varied considerably with the size of the wood meal, finer material giving more cold-water solubles and correspondingly less hot-water solubles than coarser sawdust. This fact, together with the low content of xylose residues, makes it probable that the extracted polysaccharides were located outside the secondary wall. Hydrolysis and chromatographic examination indicated the presence of the same sugars in the hot-water soluble fraction but with glucose constituting approximately half and mannose one quarter of the total amount.

The first polysaccharide, on paper electrophoresis in a borate buffer, could be resolved into two (or possibly three) components. The possible presence of an arabogalactan and a glucomannan or galactoglucomannan does not appear impossible. More material is presently being isolated with a view of preparing pure polysaccharides for structural investigations.

CONCLUSIONS

It is a rather astonishing fact that it is only within the last few years that information has been obtained as to the structure of the main wood hemicelluloses. Many details are still not clear and the constitution of the minor polysaccharides is presently largely unknown. Concerning the pectic material in wood hardly anything has been definitely established except the fact that it is present there. The structure of the polysaccharides in bark has never been investigated although such studies, dealing with the inner bark of white spruce, are now in progress in this laboratory (T. J. Painter).

Although more is known about the cellulose constituent of wood, its molecular properties in the native state cannot be considered as finally established. The nitration method of isolation is not entirely satisfactory and better procedures for estimating polymolecularity would be highly desirable.

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Growth Mechanisms in Hardwoods

DONALD A. FRASER

A review of the literature in forest tree growth is supplemented by observations during 10 years of research at the Petawawa Forest Experiment Station. The annual variations in radial growth of yellow birch trees on three soil moisture sites are described. Cambial activity at the 4-ft level was investigated by sectioning samples of bark and outer wood and by periodic measurements of radial increment with a dial gage dendrometer. The number of layers of undifferentiated cells in the cambial zone is a reliable index of the current rate of cambial activity, and when a constant minimum number of layers is reached in the fall radial growth had ceased. The time of initiation of growth appeared to be influenced by late winter and early spring temperatures, since the soil, at this time of the year at Chalk River, had always sufficient moisture for growth. On wet sites, a thick organic horizon delays the spring warm-up of the soil which consequently retards initiation of growth. Cambial activity in the stem of all trees studied had ceased by early September even on sites where neither moisture nor temperature was limiting. Cessation of growth appears to be regulated by a shortened photoperiod acting through a growth hormone mechanism. The contention of the early European workers, that the march of initiation of cambial activity proceeded from the apex to the base, was found to be true for trees studied in Ontario, and the suggestion that American trees might behave differently because of the cold winters was not substantiated. Concerning the controversy between R. Hartig and L. Jost, experiments verify the latter's theory of a stimulus, not associated with food, proceeding from the buds and developing leaves in the spring, and being responsible for the apical initiation of cambial activity. This stimulus is probably produced by a growth hormone which former workers have shown to be present. That the control of radial growth is of a hormonal nature is evinced by the continued production of springwood when β-indole acetic acid is applied in late summer. No distinct change of slope occurred in growth curves of ring-porous species, such as black ash, when the transition from vessel to fiber tracheid took place. This indicates that a regulating mechanism other than food is controlling cell differentiation. Apical and radial growth of hardwood species studied may be prolonged and influenced by long photoperiod, certain temperature regimes, growth hormones applied externally and optimum nutrient solutions. The mechanism of cellular differentiation of woody tissues is discussed.

PLANT physiologists have for many years neglected the use of trees for experimental material because of their size, the necessity of long-term experiments lasting over a number of years as well as thoroughout all seasons, and the lack of suitable trees near to most Universities. Problems assigned to graduate students are more likely to be related to tree seedlings

DONALD A. FRASER, Forestry Officer, Forest Research Division, Forestry Branch, Canada Department of Northern Affairs and National Resources, Chalk River, Ont.

rather than to mature specimens, if trees are included at all in the experimental investigations.

The literature contains many conflicting theories and observations on the growth of trees in healthy and decadent conditions. In some problems, such as "dieback of birch," the views of various investigators may be compared to the story of the seven blind men examining an elephant, each man formed his own opinion depending on the part of the animal he examined. Similar discrepancies in the results of study of initiation of cambial activity of forest trees caused me to write to the late Professor H. P. Brown of the New York State College of Forestry more than 11 years ago. Professor Brown had worked on the initiation of cambial activity some 40 years ago during his graduate studies at Cornell University and his results were somewhat at variance with those of other workers in Europe (*4, 5*). His reply to my inquiry was as follows:

> "You ask about my papers three decades back on the seasonal growth in *Pinus strobus* and *Pinus rigida*. I am reminded of the opening remarks of Mark Anthony in his funeral oration following Caesar's assassination. 'The evil that men do lives after them; the good is often interred with their bones.' I know that Priestley disagrees with me. I have always hoped to repeat my studies to disprove or substantiate Priestley's contention but alas—responsibilities increase with increasing age and I probably will never be able to take up this task. All I can say is that I reported my findings as I found them at the time. Yes, procuring cuttings from living trees is ticklish business and I had several close calls from falling. Now that I weigh 195 lbs. I am not as much of a squirrel as I was back in 1911–16."

Hardwoods (or broad-leaved trees) are, for the most part, classified in the class Dicotyledoneae (*32*) which are considered of more recent origin than that of the Gymnospermae to which the conifers belong. Since representatives with the aborescent habit are to be found in diverse families, considerable variation exists in wood structure and its morphological and physiological characteristics. Trees are perennial plants with a main stem or trunk. A layer of cells which forms the cambium has the unique quality that cells formed by it will mature not only into various types of wood tissue depending on time of year, growing conditions, and internal hormonal stimuli, but also into all the functionally complex tissues of the inner bark. This tissue plays an important role in translocation of organic compounds. The role of the apical meristem must not be forgotten since it is here that the characteristic form of the tree is laid down. We know relatively little about the control mechanism of cambial derivatives, yet I would venture a suggestion that from the study of new cell wall formation we shall learn much about the chemistry of cell wall constituents. Although the hardwoods usually have a deliquescent, broad crown, certain species have a more excurrent type of growth approximating that of conifers. The apical dominance over lateral branches is a type of growth which probably reflects a greater auxin production in the terminal bud which, in turn, regulates the growth and form of the lateral branches.

The modern concept of secondary growth in trees seems to have had its birth some 250 years ago. In 1708 de la Hire, in a work reviewed some 145 years later by Thomas Hartig (*24*), quoted another investigator to the effect that in buds and roots, in the space extending downward between the wood and bast, there is tissue which through its equal-sided division gives rise to new wood and bast units. Hartig himself was in agreement with this thesis and did much to establish its validity as opposed to such other contemporary theories as that of transformation of bast into wood or the one which considered the cambium as a nutritive fluid comparable to blood in the animal body.

In the temperate regions, there is a considerable portion of each year in which the cambium is inactive and a number of investigators have concerned themselves with its resumption of activity in the spring. Thomas Hartig (*24*) concluded that, in general, radial growth began at the tips of twigs and then gradually extended downward. He noted some exceptions, however, mentioning an oak where cambial activity began almost simultaneously over the entire trunk. According to Mer (*31*), cambial activity in oak, beech, basswood, and other trees of 25 years of age and under, begins in the youngest twigs. In older trees he described it as being simultaneous at the bases of branches and along the trunk. Robert Hartig (*23*) found that in isolated trees cambial activity started in all parts of the trunk at approximately the same time, whereas under forest conditions its initiation occurred first in the twigs whence it proceeded downward, the cessation following the same order. Hastings (*25*) stated that in broad-leaved trees radial growth did not begin until the buds opened. This has been corroborated by Buckhout (*7*) and Priestley (*35*).

Wareing (*47*) noted that rapid initiation of cambial activity throughout the tree is characteristic of ring-porous species as a class. Diffuse-porous species, on the other hand, are much slower in the basipetal movement of cambial activity in the spring. He stated that the failure to make distinction between the behavior of the two types of species may partly account for the conflicting results obtained by earlier workers.

Concerning the cause underlying the initiation of cambial activity in spring, two theories formed the basis of a controversy between R. Hartig (*23*) and L. Jost (*26*) 60 years ago and since that time no new theories have been evolved. Hartig's contention was that the stimulus to the cambium came from the bud and developing leaves in the form of increased food supply, whereas Jost believed that the initiation of growth was connected with a stimulus proceeding from the same source, but not correlated with the food supply. Later, after the discovery of auxins, Jost (*27*) identified this material as the stimulus which he had postulated, and proved experimentally that it did stimulate the cambium to activity. Other workers came to the same conclusion (*3, 6, 43, 44*). During the period of cambial activity in trees of the temperate zone, there is a change in the nature of the wood elements produced and this difference between early and late wood is responsible for the so-called annual ring. In the conifers the difference is one of size and form in the tracheids. The early tracheids (springwood) are larger and thinner-walled than the later ones which constitute the summerwood. In some species, such as white pine (*Pinus strobus* L.), tangential pitting occurring in the summer wood constitutes a further distinguishing character. In the angiosperms the spring and summerwood are distinguished largely by

a difference in the size and distribution of vessels and in some cases the characteristics of wood parenchyma.

Various theories have been advanced to explain the factors controlling the formation of spring and summerwood. Sachs (*40*) stated that the difference was entirely the result of variation in radial pressure on the cambium during the growing season. This was supposed to be at a minimum in the spring, permitting a greater expansion of the new elements, while it increased during the growing season ending with a maximum. Krabbe (*29*) disagreed with this theory and satisfied himself by experiment that supposed increase of bark pressure did not occur. Robert Hartig (*23*) suggested that the cambium was poorly nourished in the spring and the formation of the denser summerwood depended upon improved nutrition, accompanied by an increased amount of transpiration which accounted for the small size of the lumen. On the other hand, Wieler (*52*) suggested that the early wood owed its origin to better conditions of nourishment. Mer (*31*) accepted Wieler's theory with the added concept of greater activity on the part of the cambium in spring and sluggishness in the later summer being responsible for the formation of spring and summerwood.

Strasburger (*45*) accepted none of these theories but explained the formation of annual rings on a teleological basis. The springwood was the response of the plant to a demand for conducting tissue while the summerwood was formed to increase the stability of the tree. The latter factor may have been in force from the beginning but was at the start overshadowed by the former.

Schwarz (*42*) assigned the chief role in late wood formation to longitudinal pressure caused by gravity. This is in force throughout the growing season but its effects are lost at first as a result of other factors, such as nourishment, which are temporarily stronger at that time.

It was noted by Sanio (*41*) that the regularity of spring and summerwood formation, as the season progresses, is not always maintained and the so-called false annual ring observed by him has since been noted in a larger number of forms. Büsgen and Münch (*8*) quoted Kny and Jost to the effect that false annual rings were associated with defoliation and frost. They are also caused by other factors such as pressure, ligaturing, and bending of twigs (*46*).

Priestley and Scott (*36*) considered springwood formation to be associated with the opening of the buds and the extension of the new shoots in spring. They were of the opinion that the summerwood formation was related to the formation of the bud scales and the lack of water in the tree.

METHODS FOR RECORDING TREE GROWTH

In tree growth studies it seems that whether apical or radial growth was measured was dependent on the size of the tree. With seedlings one invariably finds in the literature measurements of height growth, whereas when the size of the tree exceeds the height of man (6 ft). we find the investigator's interest centered on radial growth. Part of this division of study is associated with the difficulties of measuring radial growth in seedlings, where small fluctuations of moisture content and the ratio of bark to wood thickness as well as the succulent nature of the stem, adds to the experimental error, whereas in trees taller than the height of man a tower to support the investigator is required. In hardwoods with the deliquescent or sympodial type of branching it is necessary to measure a number of apical growing points in order to arrive at a height growth representative of the tree as a whole.

Apical Growth

Measurements of apical growth in hardwoods often offer certain problems. Terminal growing points are frequently sheathed by foliar organs so that it is difficult to make mechanical contact with the actual apex. Nakashima (*33*) used a tower to support his apparatus for measuring terminal elongation. This apparatus or auximeter as it was called consisted of a recording unit driven by a clock and a device for contact with the growing tip. It was used on conifers rather than hardwoods.

Radial Growth

Various methods have been employed in the study of radial growth in forest trees. Jost (*26*) and Hartig (*23*) studied periodic growth by selecting even-aged stands where samples could be obtained from trees felled at different times during the growth period. Results obtained by this method were complicated by inter-tree variability. von Mohl (*34*) and others used calipers and tapes to measure the tree bole and this method is still widely used where great accuracy is not essential. MacDougal (*30*) developed a very efficient dendrograph which has been used by a number of workers. The apparatus is so planned that without significantly affecting the cambium, two areas of contact are maintained on opposite sides of the trunk and even small changes in diameter are recorded on a revolving drum by means of a set of levers connected with these contacts. The apparatus is, however, rather expensive and a separate instrument is required for each tree under observation. More recently Fritts and Fritts (*20*) have modified this type of dendrograph to record radial growth at one point, but a tree of about 6 in. minimum diameter at breast height is required to support the instrument.

In recent years, instruments known as dendrometers have been developed. Only one instrument is required for following the course of radial increment of many trees. All operate on the principle of measuring the change of distance between a plate fastened to the bark and a reference plane anchored in wood. Successive dendrometer measurements permit the calculation of radial increase with time.

Several dendrometers have been described (*9, 37, 50*); that employ dial gages with various means of application to the tree. During the current studies Belyea, Fraser, and Rose (*2*) developed a dendrometer that has advantages over earlier types. A standard dial gage graduated in thousandths of an inch is mounted on a triangular base. Through an aperture in the center of the base projects a moveable spindle. This spindle is connected with the apparatus so that as it moves up one thousandth of an inch, the needle on the dial moves over a distance of one unit. From the angles of the base, three pointed legs project downward. When the instrument is in use, the three legs are ap-

plied to the heads of three screws which are permanently inserted deep into the wood of the tree, while the moveable spindle impinges on the flat head of a thumb tack glued to the bark. In this manner any radial increment is registered in the dial gage by differences in readings.

A dendrometer merely records total radial increment. In the present investigation it was important to distinguish increment by swelling from that caused by cell division. For this reason methods based on sampling and microscopic study of wood and bark sections at periodic intervals were also used. In the early stages of the work, the samples were removed with a hammer and chisel, but later another method was devised which produced less injury to the tissues. In this later procedure use was made of a steel cutting tube which consisted of a $^3/_4$-in. hardened steel pipe ground to a sharp chisel edge at one end. After the outer part of the dead periderm had been carefully chipped away, the cutting tube was driven in to delimit the segment. A chisel was then inserted beside the cutting tube and served as a lever to ensure that the delimited segment was removed from the tree with the tube. The segment was pressed out of the tube by means of a wooden rod. It was then trimmed, labeled as to date, height, and tree, and preserved in 70% alcohol. This process produced less injury to the delicate tissue than was produced in earlier operations with the chisel alone. Neither dendrometer nor sectioning can give a completely accurate picture. The former, as mentioned above, merely records total radial increment without distinguishing changes caused by cell division and swelling, whereas the latter method is open to criticism for a number of reasons. Each sample taken leaves a wound which may affect subsequent growth and successive samples cannot be taken from the same position with the result that the variation in the amount of cambial growth on different sides of the tree complicates the results.

INITIATION OF CAMBIAL ACTIVITY

Before considering the internal mechanism of growth in hardwood trees it is necessary to evaluate the relation between apical and radial growth as well as the initiation of cambial activity. Since the work of Brown (*4*, *5*) and Knudson (*28*) on the initiation of cambial activity, the tendency has been to accept their conclusions as applicable to trees growing in the temperate climate. For example, Eames and MacDaniels (*12*) state: "There is no uniformity in the position of first growth in the cambium; this is often in the central part of the tree, extending then to all parts, but cambial growth may also start at the base of the tree or at tips of twigs." While Priestley's results (*35*) were in agreement with those of earlier European workers suggesting the initiation of cambial activity at tops of trees and tips of branches, he went on to say, "we must remember, in connection with the North American work that what is seen in spring may be the resumption of cambial activity at a point where it was arbitrarily stopped in the autumn by the advent of freezing temperatures, and that conditions may be different where the winter is milder." In view of these statements and the importance of the problem from the standpoint of deciding the nature of the stimulus for renewed cambial activity, Fraser (*14*) made a number of observations on Canadian trees. In all the trees investigated, initiation of growth proceeded from above downward or, from tips of branches inward. Moreover it was possible to obtain good evidence as to the time of initiation and cessation of cambial growth in a considerable number of Canadian trees (*14*, *16*). It was found that in every case the annual ring was completed long before the onset of cold weather; thus Priestley's suggestion that in American trees cambial activity might be stopped by frost and proceed in spring from the point where it left off in the previous fall is not valid. It is, therefore, pertinent to inquire once again whether the concept of Hartig or Jost may not have been substantially correct.

An experiment which may have had some bearing on Hartig's theory was performed on a branch of red oak (*Quercus rubra* L. V. *borealis* (Michx. f. Farw.)) growing at Chalk River. On August 15, after the normal annual ring for 1950 was complete and cambial cell divisions had ceased, two 150-watt bulbs with reflectors were arranged so that their light shone on the leaves of this particular branch from 6 p.m. to 10 p.m. every evening, thus increasing the photoperiod to that of June 21. The leaves on this branch remained green after the others had taken on autumn color and fallen. In fact, they remained apparently in their usual summer condition, up until the time of the first severe frost of September 29. Anatomical investigation disclosed that this illuminated branch was full of starch whereas the majority of cells of the nonilluminated branch were devoid of starch. It seems evident that the green leaves under artificial lighting had been producing an abundance of food and, if Hartig's theory were correct, one might hope to see the beginning of a new annual ring in the cambial region. Examination of sections through the cambial regions in the two branches revealed no evidence of a renewal of radial growth.

After the discovery of plant hormones, Jost (*27*) strengthened his theory by applying auxin to a sunflower stem and so increasing the size of the vascular bundles presumably by increased cambial growth. Snow (*43*), Brown and Cormack (*6*), Wershing and Bailey (*51*), and Fraser (*13*) have also succeeded in inducing cambial division in twigs by the application of heteroauxin (β-indole acetic acid).

APICAL AND RADIAL GROWTH

The regular alternation between rest and growth which occurs in our woody plants is partly a response to certain external conditions; their nature depends also on the species under study.

An examination of apical and radial growth in hardwood trees growing at Chalk River in 1955 showed a number of interesting phenomena. Apical growth in black ash (*Fraxinus nigra* Marsh.) started in the leader and larger side branches on May 4 and continued at fairly constant rate until June 1 (Fig. 1). By June 10, apical growth in both leader and side branches had ceased. The leader remained dormant until July 1 when apical growth resumed and continued for 2 weeks forming a so-called Lammas shoot (*8*, p. 10). Lammas shoots form in a number of hardwood species including oak and beech and the tendency of their formation is greater in younger trees than in older ones. Nutri-

tion, accumulated reserve materials, water supply, and weather seem to be involved. Büsgen and Münch (*8*) state that summer rainfall promotes Lammas shoot formation. This statement is substantiated by formation of Lammas shoots in young trees in a nursery under the influence of growing near a water sprinkler which had been inadvertently left running for about 10 days (J. Duffield, personal communication) during a hot California summer.

In black ash at Chalk River, initiation of radial growth at the top of the 1954 internode (Fig. 1) preceded that at the bottom of the tree by 1 week. The number of undifferentiated cells in the cambial zone increased two to threefold when the cambium was most active, and decreased to a constant number at the end of the growing season. Constancy in number of undifferentiated cells coincided with a comparative constancy of dendrometer readings at the end of the growing season.

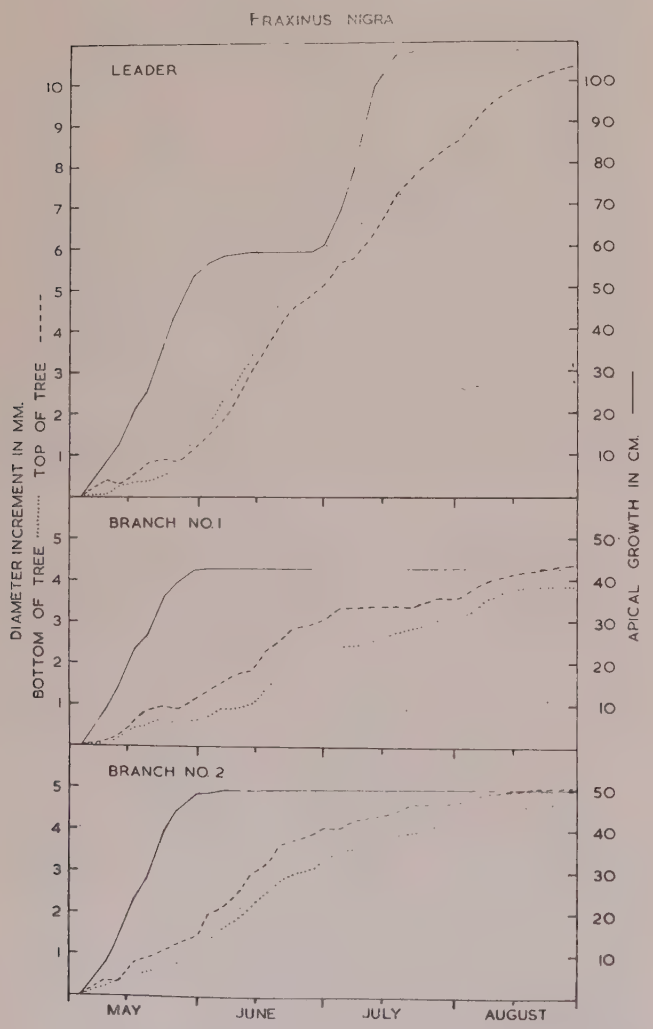

Fig. 1. Apical and diameter growth of leader and two branches of a young black ash tree

Diameter growth measured at the top and bottom of the main axis and side branches, respectively

By comparing the results of anatomical samplings early in the season with corresponding dendrometer readings, a swelling is invariably found before any wood cells have been laid down. After the initial lag, the radial increment curve assumes a sharp upward rise marking the period of active cell division in the cambium. Near the end of the season, usually in August, a third phase is delimited, when the slope of the curve

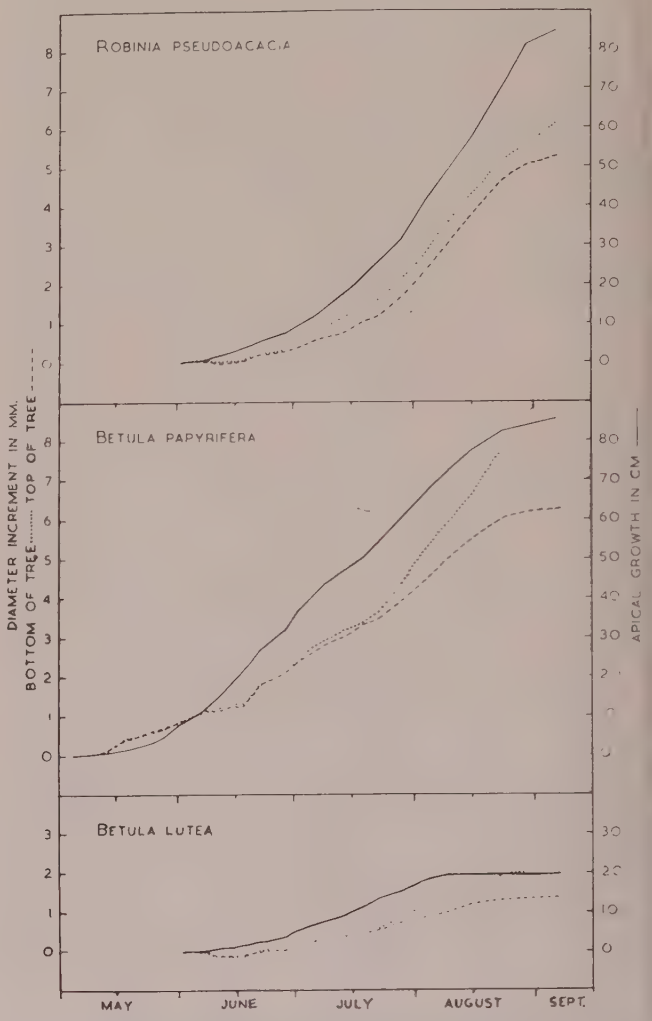

Fig. 2. Apical and diameter growth of leader and trunk of young black locust, white, and yellow birch trees

becomes very slight. The increment during this last phase rarely amounts to more than 5 or 10 micra, and probably represents the final maturation of differentiating tissue. That the more vertical part of the curve represents the period of cambial activity has been borne out by a study of all sectional material available (*16*). In most instances the line of demarcation between these phases is quite distinct; however, where total amount of radial growth is relatively small, the change in slope of the curve is gradual, making separation of the different growth phases more difficult.

Initiation of apical and radial growth varies both from species to species and from year to year. For instance white birch (*Betula papyrifera* Marsh.) started elongation of shoots by mid-May (Fig. 2) with swelling of the cambium followed by cell division which continued through the summer until the end of August. Yellow birch (*Betula lutea* Michx.f.) was some 2 weeks later in its initiation of growth and its apical growth had ceased by early August and cambial activity shortly thereafter. Black locust (*Robinia psuedoacacia* L.) had approxi-

mately the same time of initiation of apical and radial growth as yellow birch (i.e., early June) but its termination was closer to that of white birch (end of August). No distinct change of slope occurred in radial

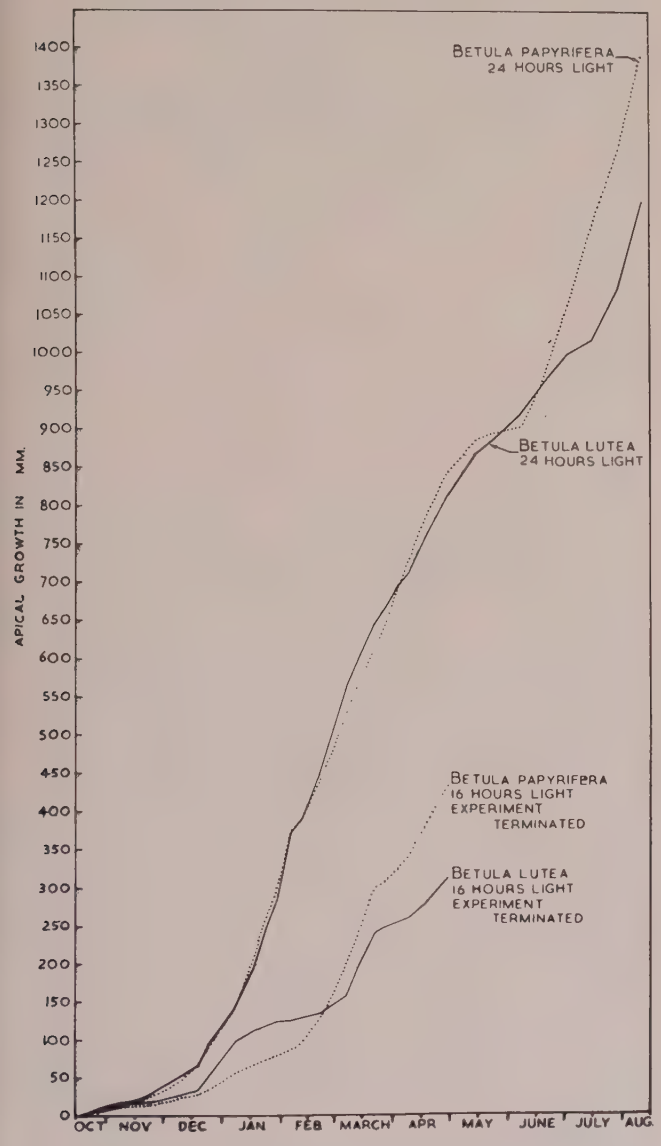

Fig. 3. Apical growth of white and yellow birch seedlings under 24 and 16-hr. photoperiods

growth curves of ring porous species such as black ash or black locust when the transition from vessel to fiber tracheid took place. This indicates that a regulating mechanism other than food is controlling cell differentiation. Cambial activity in the stem of all species studied had ceased by early September even on sites where neither moisture nor temperature was limiting. The factor which appeared to influence the cessation of both apical and radial growth was the shortened photoperiod which at the latitude of Chalk River (46° N.) was 15 hr. 35 min. on June 21, and was down to 13 hr. 10 min. by August 31. This indicated that a 16-hr. photoperiod might give continuous growth of young birch trees and thus provide material for other physiological experiments in progress (*17*). Growth of white and yellow birch seedlings under 16 and 24-hr. photoperiods (Fig. 3) shows that this supposition was correct. The seeds of these species were germinated in October and kept under these two photoperiods at 70°F., until at the end of 6 months when the 16-hr. photoperiod experiment was discontinued and the 24-

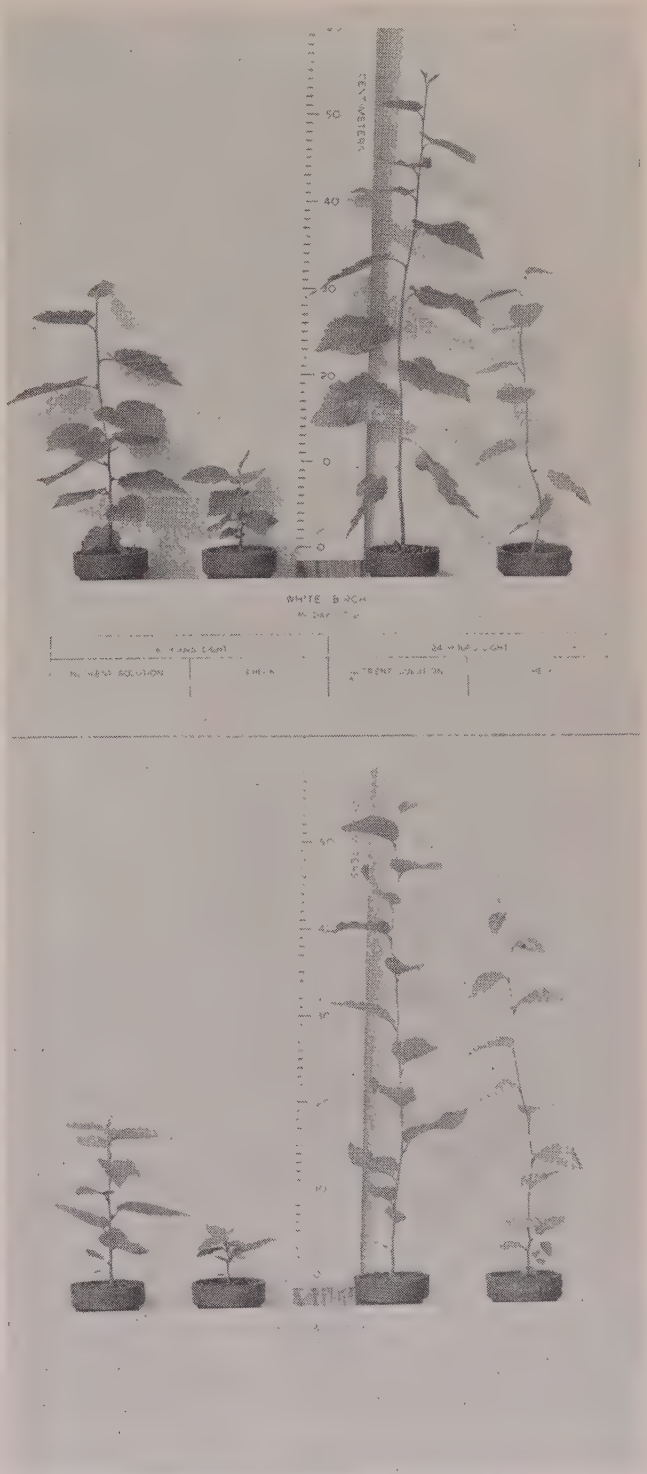

Fig. 4. White and yellow birch seedlings 135 days old, grown under 24 and 16-hr. photoperiods with and without nutrient solution

hr. photoperiod material was transferred to a 16 and 8-hr. cycle of 80 and 57°F., respectively.

Apical growth of both white and yellow birch under 24-hr. photoperiod followed the same pattern reaching

a height of over 1200 mm. (4 ft.) in 9 months. Continuous growth was also obtained with the 16-hr. photoperiod, but its rate was only about half of those seedlings growing under 24-hr. light. The effect of photoperiod as well as that of the addition of nutrient

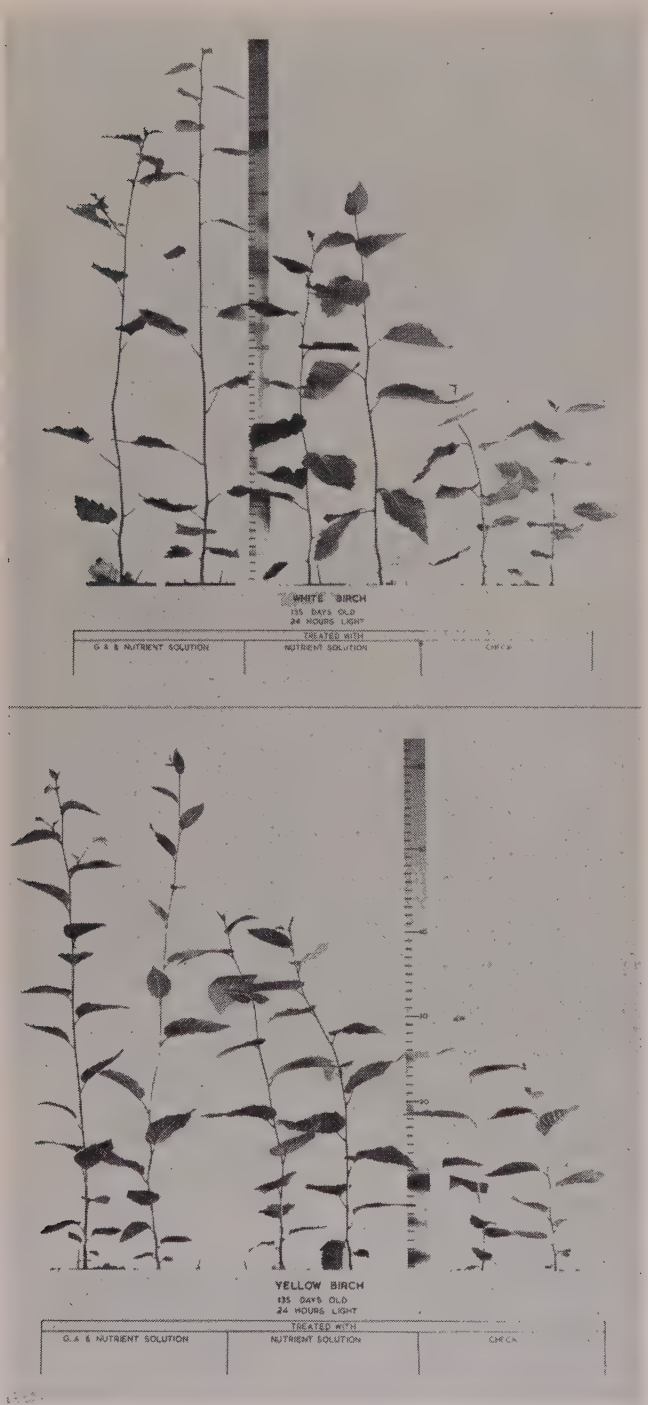

Fig. 5. White and yellow birch seedlings, 135 days old, grown under 24-hr. photoperiod, treated with gibberellic acid and nutrient solution, nutrient solution alone and without nutrient solution

solution on the growth of white and yellow birch seedlings (Fig. 4) indicated at the end of 135 days that optimum soil nutrients increased apical growth under both light regimes. The control or check plants were grown under light conditions described but lacking addition of nutrient solution or treatment with gibberellic acid.

Gibberellic acid was applied in 1% concentration in lanolin at 2-week intervals during the last month of seedling growth (Fig. 5). Here again there was accelerated growth although the treated seedlings were rather spindly and some of them could not maintain themselves erect without mechanical support.

Effect of Environment on Radial Growth

Soil Moisture. The variation of environmental factors and growth of hardwood species at Chalk River was discussed in detail by Fraser (*15–19*). The average

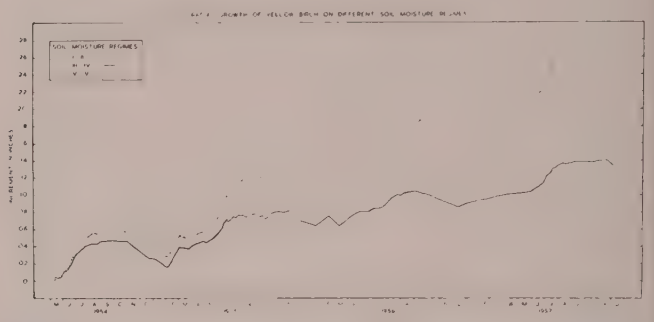

Fig. 6. Average radial growth of mature yellow birch trees growing on moisture regimes I–II (adequate moisture); III–IV (moist); and V–VI (wet)

radial growth of mature yellow birch (Fig. 6) on three different soil moisture sites from 1954 to 1957, inclusive, shows considerable seasonal and annual fluctuation. To the three summer phases of radial growth: (1) swelling or hydration, (2) cell division, (3) final maturation, is added a fourth phase, that of dehydration indicated by a shrinkage in radial girth as winter approaches and the tree becomes resistant to frost. The bark and cambial tissues may swell through partial hydration during a midwinter thaw as evinced in February of 1955 and 1956. The trees growing on sites with optimum moisture showed the greatest growth (upper curve, Fig. 6) whereas those on the wetter soils of the experimental plot had less radial growth. It is considered that the water-logged soils impeded uptake of nutrients, adversely influenced soil aeration and had a lower soil temperature especially in the earlier part of the growing season.

DISCUSSION

The studies at Chalk River indicate interrelations between tree growth, site, and climatic variations. The time of initiation of growth is considered to be controlled by winter and early spring temperatures accompanied by a lengthening day. The soil at this time of the year at Chalk River always has sufficient water for growth. Cessation of growth appears to be regulated by a shortened photoperiod acting through a growth hormone mechanism. Apical and radial growth, which in some species may continue into late August, slowed down quite independently of early autumn frosts. That the control of radial growth is of a hormonal nature is evinced by the continued production of spring wood when β-indole acetic acid is applied in late summer. The fact that no distinct change of slope occurred in growth curves of ring porous species such as black ash when the transition from vessel to fiber tracheid took place indicates that a regulating mechanism other than food is controlling cell differentiation.

Experiments at Chalk River and elsewhere (*10, 11, 14, 17, 48, 49*) indicate that many trees are sensitive to changes in length of day. Seedling growth may be prolonged indefinitely under long day conditions as shown in the white and yellow birch experiments, whereas short days cause the cessation of apical growth. Seedlings which usually grow in rapid flushes or sudden increases in apical growth (*Quercus* spp.), maintain a series of growth flushes under long days (*47*). These light-controlled tree reactions are regulated by a reversible photoreaction which has two spectral regions of maximum efficiency; one in the red and the other in the far red. This reversible photo-reaction occurs in most plants even where the photoperiodic control of flowering is not exhibited. There are other light-controlled responses which are mainly effective in the blue region and are probably not reversible (*11*). Richardson (*38, 39*) has shown that a shoot temperature of 41°F. in *Acer saccharinum* L. inhibited bud expansion but does not prevent the export of growth factor to the roots. It is of interest to note that yellow birch seedlings brought into a dormant room at 34°F. in October, produced small leaves 3 months later at this low temperature. There was about 50 ft. candles illumination for 16 hr. per day at the time. The leaves were rather thin and appeared to wilt when they had reached about 1 in. in length. It indicates, however, that cell division may take place at a low temperature.

In tree growth apical initiation of cambial activity is associated with auxin production in the bud, and low content of free auxin (as compared with inactive bound auxin) is indicative of flowering conditions. Auxin probably influences the formation of springwood through its effect on increased suction pressure within the cambial cell, increased respiratory activity and in delaying the formation of calcium pectate in the primary wall.

It is considered that ring porous species have a high auxin production during the formation of springwood with a distinct threshold level marking the transition from spring to summerwood. Audus (*1*) quotes Gautheret's (*21, 22*) group at the Sorbonne who demonstrated that heteroauxin (β-indole acetic acid) was essential for growth of isolated plant fragments in tissue cultures. In these cultures auxin induced, in the ascending concentration series, first cambial activity at 1 p.p.m., then the initiation of roots, followed by the inhibition of buds. At 10 p.p.m. auxin, growth was rapid, unregulated, and produced tumors. It is probable that this tissue culture research technique will greatly assist in clarifying the various mechanisms involved in the differentiation of woody tissues.

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Pulp Bleaching with Sodium Chlorate

W. H. RAPSON, C. B. ANDERSON, and R. W. MILLEN

The direct use of sodium chlorate for pulp bleaching without first converting it into chlorine dioxide would save a great deal of capital and operating cost in pulp bleach plants. Sodium chlorate bleached pulps in strongly acid solutions, but the latter seriously degraded the cellulose. By using vanadium pentoxide as a catalyst, the acidity required was greatly lowered, but the hydrolytic attack on the cellulose was still serious under practical bleaching conditions (13% consistency, pH 2, 70°C., 4 hr.). "Activated chlorate," supplied by Azienda Brevetti Industriali of Milan, Italy, gave similar results. The conditions (time, temperature, consistency, pH, ratio of vanadium oxide to chlorate, and ratio of chlorate to pulp) were varied systematically and brightness, color stability, viscosity, and hot alkali solubility were measured. By using very high consistency at room temperature with catalyzed acidified chlorate and very long bleaching time (2 to 14 days at 23°C.) good bleaching of partly bleached pulps was accomplished, with only a little degradation. With unbleached pulp these conditions led to severe degradation. The addition of small amounts of sodium chlorate to the chlorine in chlorination, as recommended by Heitman, had a negligible effect on pulp brightness but raised the viscosity significantly, while larger amounts lowered the brightness. By adding vanadium pentoxide with the chlorate the brightness increased continuously with increasing chlorate. In all direct comparisons made in this investigation chlorine dioxide gave higher maximum brightness with much less than the equivalent amount of sodium chlorate with no significant degradation of the pulp. Therefore, unfortunately, conditions have not yet been found under which sodium chlorate can displace chlorine dioxide for pulp bleaching, either cost-wise or quality-wise.

Sodium chlorate is now a widely used raw material for pulp bleaching. However, it is not used directly, but is converted at the mill into chlorine dioxide, which bleaches pulp to high brightness without significant damage to its strength properties (*1*).

It has long been the goal of many research workers to find a way of bleaching pulp directly with sodium chlorate, thereby avoiding the cost and inconvenience of producing chlorine dioxide from it. Sodium chlorate is relatively cheap and contains six oxidizing equivalents per mole. If these could all be usefully used under conditions which could be achieved economically and which would not damage the pulp, a great step forward in pulp bleaching would be made.

This paper summarizes the attempts which have been made at the University of Toronto to use chlorates directly for bleaching pulp.

Unfortunately, chlorates do not readily give up oxygen in water solution. Only when a chlorate solution is acidified does it act as an oxidizing agent. It might be assumed that chloric acid is the actual substance which gives up oxygen, since the higher the acidity the faster a chlorate solution oxidizes.

W. H. Rapson, Professor of Chemical Engineering, C. B. Anderson, Research Assistant, and R. W. Millen, Student, Department of Chemical Engineering, University of Toronto, Toronto, Ont.

Research on the mechanism of formation of chlorine dioxide showed that this substance is formed from sodium chlorate in strongly acid solution in the presence of any reducing substance, as long as traces of chloride are present in the solution (*2*). Since lignin is a strong reducing agent, it was hoped that it would form chlorine dioxide in an acid chlorate solution, and that the chlorine dioxide would also act as a bleaching agent.

Therefore, sulphite pulp which had been chlorinated to demand and extracted with sodium hydroxide solution in a pulp mill was treated with 2% $NaClO_3$ on pulp, at 6% consistency, at 50°C., for 3 hr., in sulphuric acid solution of increasing normality. The results are shown in Fig. 1.

Brightness increased very little until the acidity rose above 5 *N*, after which it increased sharply to a maximum at 9 *N*. It is significant that these acidities are precisely those found to be minimal and optimal for manufacturing chlorine dioxide from sodium chlorate and any reducing agent. However, the chlorine dioxide which was formed in these experiments does not bleach pulp very efficiently at this very high acidity. This may be the reason for the failure to achieve very high brightness in these experiments.

It was thought that a separate better reducing agent would react with the chlorate to form chlorine dioxide, and that the latter would then bleach the pulp. Accordingly, 0.5% formaldehyde on pulp was included in a similar series of experiments. The formaldehyde reacted with the chlorate as indicated by the increased consumption of the chlorate at each acidity. Brightness was a little higher at the lower acidities but was lower at the higher acidities in the presence of the formaldehyde (Fig 1).

The pulp was very seriously degraded in both series of experiments. The viscosity dropped as the acidity increased in a very nearly linear manner. The hot alkali solubility increased sharply as the acidity increased, above 5 *N*, both curves being similar in shape to that for brightness without formaldehyde.

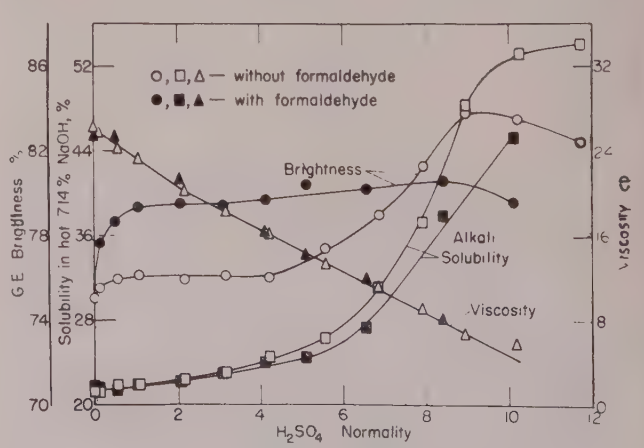

Fig. 1. $NaClO_3$ bleaching of semibleached sulphite pulp

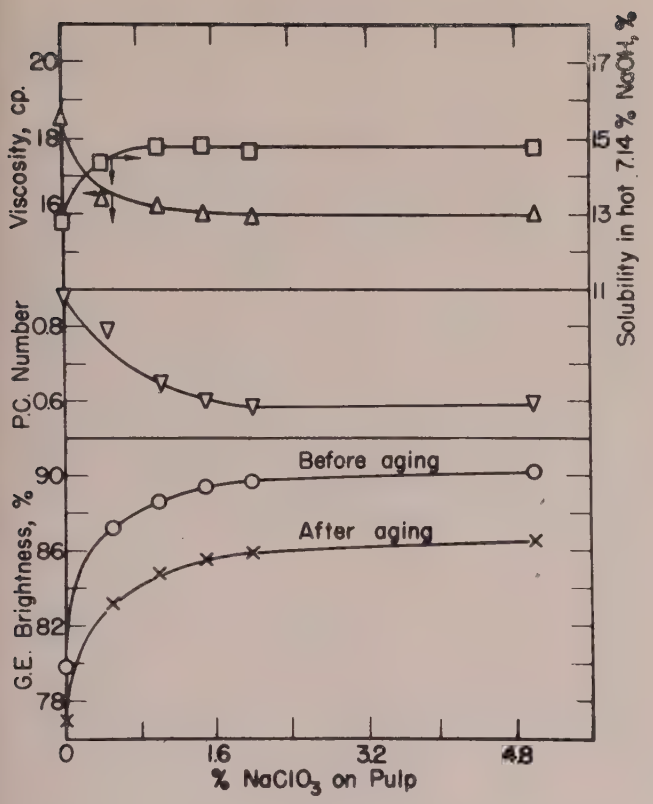

Fig. 2

This shows that it is the chlorate which introduces the carbonyl groups which confer solubility in hot alkali, and not the chlorine dioxide formed or the acidity. If it were the ClO_2, a different shaped curve should be found with formaldehyde. If it were the acid, the hot alkali solubility curve should not change abruptly at about 5 *N* sulphuric acid.

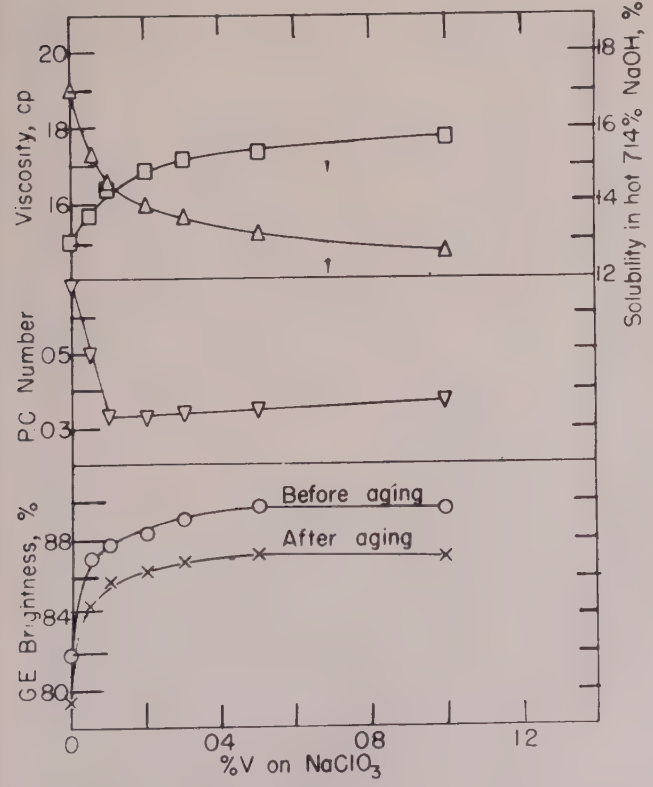

Fig. 3

BLEACHING WITH CATALYZED SODIUM CHLORATE

In August, 1957, Marpillero (*3*) announced the commercial availability of "activated chlorate" called "ACl" which was said to be a good pulp bleaching agent. The nature of the "activation" of the chlorate has not been disclosed.

Spectroscopic analysis showed "ACl" to contain about 0.18% vanadium and 0.16% molybdenum. Synthetic mixtures of pure sodium chlorate and vanadium pentoxide were found to be very similar to ACl in their behavior, but the effect of molybdenum was negligible. Therefore, a systematic investigation of the effect of all the variables involved in bleaching pulp with sodium chlorate and vanadium pentoxide was undertaken.

Milas in 1928 (*4*) reported the simultaneous oxidation and esterification of six primary alcohols by sodium chlorate, catalyzed by vanadium pentoxide in neutral or acid solutions. In 1935 he noted (*5*) that a mixed catalyst of 10% molybdenum oxide and 90% vanadium pentoxide could also bring about this oxidation. In 1936 Bates (*6*) investigated the use of vanadium pentoxide as a catalyst for sodium chlorate in weed destruction.

OPTIMUM CONDITIONS FOR BLEACHING WITH SODIUM CHLORATE AND VANADIUM PENTOXIDE

Some preliminary experiments showed that conditions similar to those suggested by Marpillero, about 4 hr., at 70°C., at 13% consistency, with 1.2% $NaClO_3$ on pulp with 0.2% V on chlorate, at pH 2 were near optimum. Therefore, the effects of the six variables, time, temperature, consistency, chlorate-pulp ratio, catalyst-chlorate ratio, and pH, were investigated

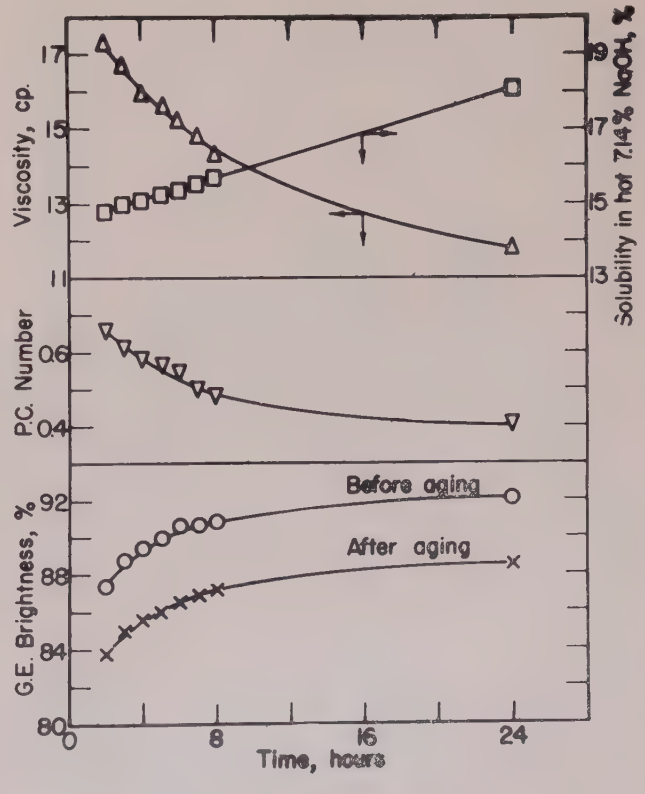

Fig. 4

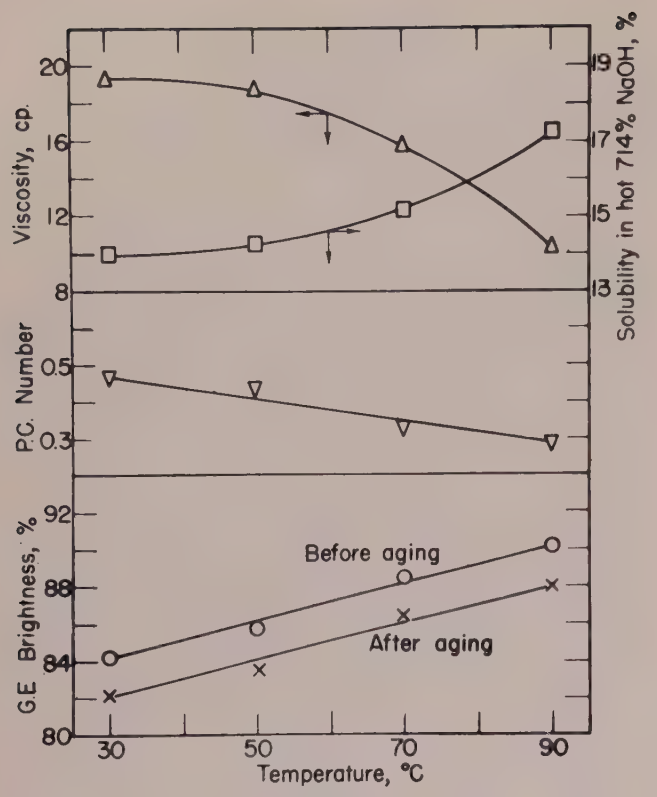

Fig. 5

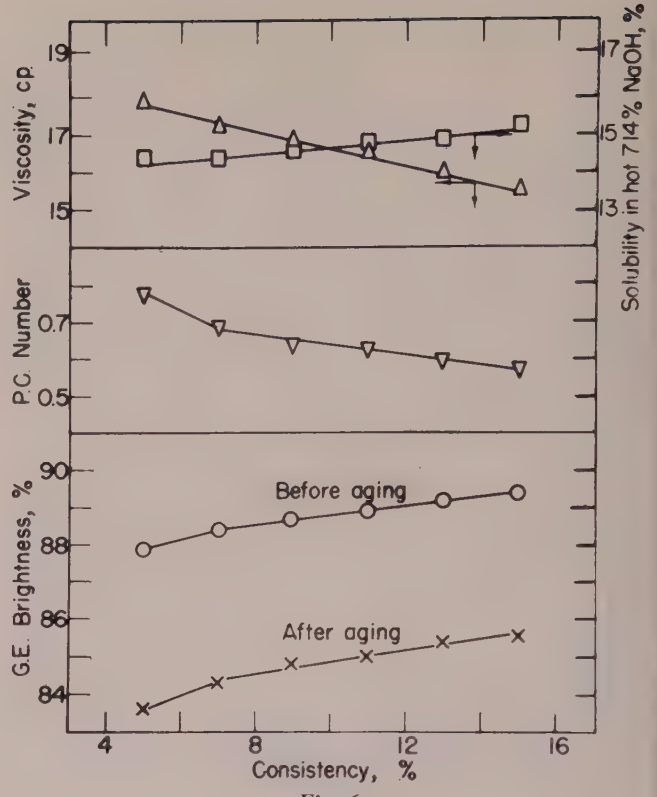

Fig. 6

systematically by fixing five variables at these values while varying the sixth (7).

A kraft pulp was used, partially bleached by four stages; chlorination, caustic extraction, chlorine dioxide treatment, and caustic extraction to 77.5 brightness. The results are shown in Figs. 2 to 7.

Chlorate-Pulp Ratio

As the ratio of sodium chlorate to pulp increased, brightness increased, color stability improved, viscosity dropped, and hot alkali solubility increased (Fig. 2). Since the changes were slight with more than 1.2% $NaClO_3$ on pulp, this ratio was fixed at this value for the study of the other variables.

Vanadium-Chlorate Ratio

As the ratio of vanadium (in V_2O_5) to chlorate increased, brightness increased, color reversion decreased, viscosity dropped, and hot alkali solubility increased (Fig. 3). Without the catalyst no significant bleaching occurred, although the viscosity dropped from 21.4 to 20.0 cp., presumably due to the low pH alone. The 0.2% V on chlorate was nearly as effective as larger amounts, and significantly better than smaller amounts, and hence this ratio is about optimum and was used in all other experiments. This checks very nicely with the spectroscopic analysis of ACl, showing that the commercial activated chlorate sample from Europe has about the optimum amount of vanadium in it.

Time

With fixed amount of chlorate and vanadium, the bleaching improved with time (Fig 4). Although 6 hr. would be much better than 4 hr. for brightness and color stability, viscosity dropped sharply as time increased. Thus, 4 hr. was chosen as being the best compromise between brightness gain and strength loss, although the degradation was rather serious in 4 hr. at 70°C.

Temperature

Brightness increased and color reversion improved in a nearly linear manner as temperature was increased with all other variables fixed (Fig. 5). Unfortunately,

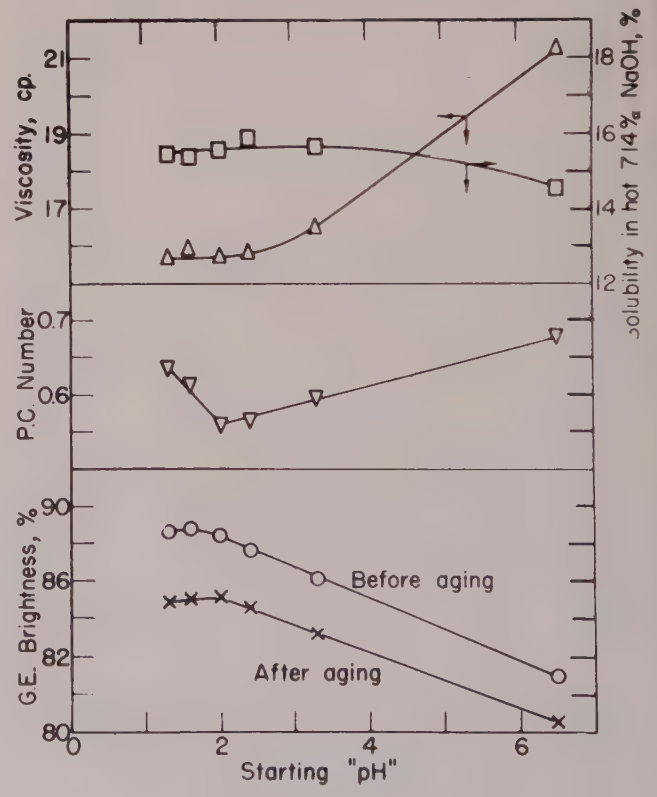

Fig. 7

Table I. Chlorine Dioxide Bleaching of Semibleached Kraft Pulp

Conditions: 8% consistency, 70°C., pH 6, 3 hr.

% ClO_2 on pulp	G.E. brightness, % Before aging	G.E. brightness, % After aging	P.C. No.	Viscosity, cp.	7.14% hot NaOH sol., %
0	77.1	74.5	1.04	24.9	14.0
0.2	91.5	88.6	0.33	25.9	14.4
0.4	92.7	88.9	0.40	24.5	14.2
0.6	93.8	90.1	0.34	23.3	14.1
0.8	93.8	90.6	0.28	22.6	14.0

viscosity dropped and hot alkali solubility increased as temperature rose, indicating severe oxidative and hydrolytic degradation. Although 70°C. was chosen for the fixed temperature for studying the effect of the other variables because it was possible to lower the time to a usable range, it is obvious that lower temperature and much longer time would give better brightness improvement with less degradation.

Consistency

The effect of consistency was considerably less than that of the other variables, as might be expected (Fig. 6). As the consistency increased, which means as the ratio of pulp to water increased, and therefore as the concentration of sodium chlorate increased (since the ratio of chlorate to pulp was fixed), there was a nearly linear increase in brightness, color stability and hot alkali solubility and decrease in viscosity. Therefore 13% consistency was adopted as the highest which would likely be used in a continuous bleaching tower at 70°C. for 3 hr.

pH

The most important variable was found to be starting pH (Fig. 7). Brightness and color reversion increased sharply and viscosity dropped sharply as pH dropped from pH 6.5 to pH 2.0, but lower pH did not make much difference. The sharp break about pH 2 indicates this to be optimum for the other fixed conditions.

COMPARISON WITH CHLORINE DIOXIDE

The same sample of semibleached sulphate pulp was bleached with chlorine dioxide for comparison. Varied amounts of chlorine dioxide were used, at 8% consistency, at 70°C., for 3 hr., at pH 6, maintained with a KH_2PO_4 buffer (Table I).

Only 0.2% ClO_2 on pulp was required to raise the G.E. brightness of this pulp from 77.1 to 91.5. Larger amounts increased the brightness to 93.8 with 0.6% ClO_2 on pulp. Color reversion was very low, and there was no significant drop in viscosity or increase in hot alkali solubility, indicating an extremely stable pulp.

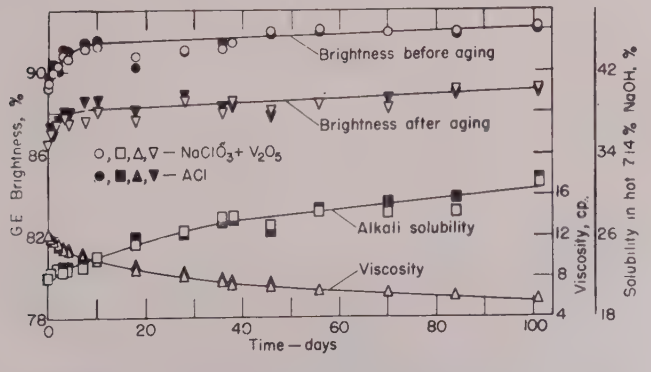

Fig. 8. Chlorate steep bleaching sulphate pulp

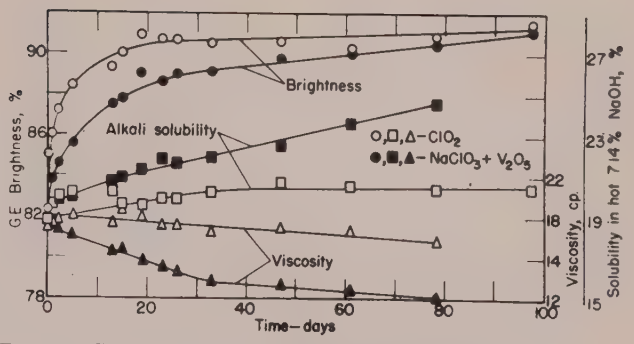

Fig. 9. Comparison of ClO_2 and $NaClO_3$ + V_2O_5—steep bleaching of sulphite pulp

Since 0.2% ClO_2 is equivalent to only 0.26% sodium chlorate, it is obvious that chlorine dioxide is much more efficient for bleaching, as well as much less degrading. Furthermore, in spite of the high capital investment required for making chlorine dioxide from sodium chlorate, it is much more economical to make this conversion because the chlorine dioxide is so much more effective, which means that a much smaller amount is required.

TESTING OTHER METALS AS CATALYSTS

In order to evaluate quickly the catalytic properties of a number of metal ions for bleaching with sodium chlorate, partly bleached sulphite pulp was treated with 2% sodium chlorate on pulp, with 1% of each metal ion on chlorate (in the substances shown in Table II), at 12% consistency, at 70°C., at pH 1.5 to 1.9, for 4 hr.

Among the metals tested, although osmium, cerium, manganese, and tin may have had a slight effect, vanadium was the only one which raised the brightness substantially. The fact that both samples of ACl gave similar results to the chlorate and vanadium would strongly suggest that vanadium is the "activating" agent, even if spectrographic analysis had not revealed its presence.

"STEEP" BLEACHING AT HIGH CONSISTENCY AT ROOM TEMPERATURE

Recently, Marpillero (*8*) has proposed the use of "steep" bleaching conditions with "activated chlorate,"

Table II. Testing Catalytic Activity of Various Metals. Chlorate Bleaching of Sulphite Pulp

Conditions: 2% $NaClO_3$ on pulp, with 1% of metal in compound shown, 12% consistency, 70°C., pH 1.5–1.9, 4 hr.

Metal	Compound	G.E. brightness, %
No chlorate	...	82.3
Chlorate, no catalyst	...	81.8
Bi	$BiCl_3$	81.2
Fe	$FeCl_3$	81.5
Co	$CoCl_2$	82.0
Cr	$CrCl_3$	82.0
Ni	$NiCl_2$	82.3
Mo	H_2MoO_4	82.3
Sn	$SnCl_2$	82.5
Mn	$MnCl_2$	82.6
Ce	$Ce(SO_4)_2$	82.8
Os	OsO_4	83.0
V	V_2O_5	85.9
ACl (1)		85.4
ACl (2)		85.3

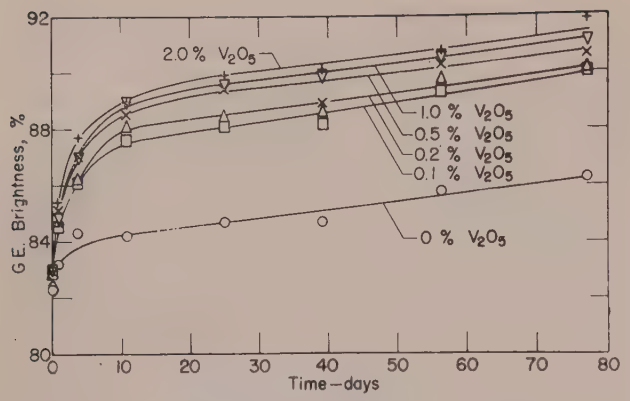

Fig. 10. Varied catalyst—chlorate ratio sulphite pulp

that is, high consistency at room temperature for a long time, as sometimes used with hydrogen peroxide (*9*). These conditions favor higher brightness with less degradation even though higher acidity is used than at the higher temperature.

These conditions were therefore tried out with a bleached southern pine sulphate pulp. The pulp was dispersed in a solution of sodium chlorate and vanadium pentoxide, containing sufficient hydrochloric acid to give pH 0.9, and then filtered and squeezed in a press to 48% consistency. The treated pulp was sealed in a jar and samples were removed for analysis after 4 hr., then daily, then at less frequent intervals for 103 days.

In one such experiment after preparation the pulp contained 0.72% ACl and 1.19% HCl, and in another 0.76% $NaClO_3$, 0.0019% V_2O_5 and 1.26% HCl. As may be seen in Fig. 8, the results are nearly identical, showing that "activated chlorate" and the mixture of $NaClO_3$ and V_2O_5 behave the same.

Brightness rose from 86.0 to 89.2 as soon as the pulp was prepared, probably due to the acid treatment and wash which the sample received. As time went on, the brightness rose slowly to 91.1% after 3 days, and very slowly to 92.8 after 103 days. Viscosity dropped steadily from 12.0 after mixing to 10.8 after 3 days and to 5.8 after 103 days. Hot alkali solubility increased steadily from 21.9 to 31.3% after 103 days.

In order to compare sodium chlorate with chlorine dioxide under these conditions, a partly bleached sulphite pulp was treated with 1.8% sodium chlorate, 0.0045% V_2O_5, and 3% HCl on pulp (pH 0.90), at 27% consistency, at 25°C. Simultaneously, another sample of the same pulp was treated with 0.9% ClO_2 on pulp, at 27% consistency, at 25°C., at pH 4.7. Each sample was placed in a sealed fruit jar. Samples were removed periodically, washed, treated with sulphur dioxide in water and washed again.

With chlorine dioxide (Fig. 9) the brightness rose from 82.3 to 85.0 within 2 hr., while the sodium chlorate and vanadium pentoxide took more than 50 hr. to reach the same brightness. Furthermore, the chlorine dioxide treated pulp continued to rise in brightness at a similar rate to that of the chlorate treated pulp, maintaining more than 2 points higher brightness for more than 20 days. Both pulps then slowly approached the same maximum brightness. After 100 days the brightness of the chlorine dioxide treated pulp was 91.8 and the chlorate treated pulp 91.3. Color reversion was about the same in both cases.

The viscosity dropped steadily as the chlorate

Table III

Bleach	pH Start	pH Finish	G.E. brightness, % Before aging	G.E. brightness, % After aging	Hot 7.14% NaOH sol., %	Viscosity, cp.
$NaClO_3$ + V_2O_5	1.1	1.1	85.5	80.8	20.6	13.1
ClO_2	5.3	3.3	90.8	84.3	19.6	18.8

bleaching progressed, but it rose slightly with the chlorine dioxide treatment, dropping slightly below the original only after 33 days, indicating very little degrading action of chlorine dioxide.

Hot alkali solubility rose slowly from 18.8 to 24.6% with the chlorate treatment, but only to 20.4% with chlorine dioxide.

Again it is confirmed that chlorine dioxide gives better brightness faster than the chlorate does, with no damage to the cellulose, with less than half the equivalent amount of chlorate.

In order to compare the "cold steep" bleaching with that at higher temperature for shorter time, the same sulphite pulp was treated with the same amounts of chlorate (1.8% on pulp) and vanadium pentoxide (0.25% on chlorate), but less hydrochloric acid (1.8% on pulp) in one case, and with the same amount of chlorine dioxide as above (0.9%). The other conditions for both were 10% consistency, 70°C., for 4 hr. The results are shown in Table III.

This shows that the chlorine dioxide gave 90.8 brightness in 4 hr. at 70°C. which was as high as in 17 days at 25°C., with slightly better color stability, with no degradation. The catalyzed chlorate raised the brightness only to 85.5 in 4 hr. at 70°C., which was achieved in 4 days at 25°C. with less drop in viscosity. Thus there is no advantage in the "cold steep" method with chlorine dioxide, but there is a positive advantage in it as far as pulp quality is concerned with catalyzed chlorate.

EFFECT OF VARIED RATIO OF VANADIUM PENTOXIDE TO SODIUM CHLORATE IN COLD STEEP BLEACHING

Partly bleached sulphite pulp was treated with 2.3% $NaClO_3$ on pulp, at pH 0.6, at 23°C., with 0, 0.1, 0.2, 0.5, 1.0, and 2.0% V_2O_5 $NaClO_3$. Results are shown in Fig. 10.

These experiments show that the effect of the vanadium pentoxide is truly catalytic. Without the catalyst the chlorate bleached the pulp very slowly. A small amount of catalyst increased the rate of

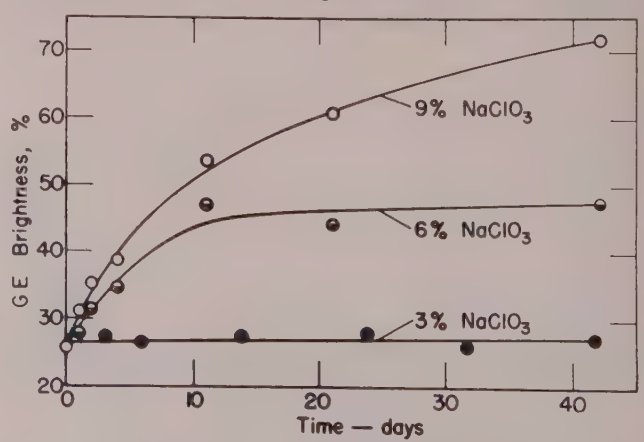

Fig. 11. Chlorate steep bleaching unbleached kraft pulp

bleaching a great deal. While larger amounts increased the bleaching rate, a twenty-fold increase in vanadium pentoxide made only a relatively small change in the rate.

The data for the effect of the catalyst on color reversion, viscosity, and hot alkali solubility are not given because they are all similar to those in Fig 9. The general statement can be made that these properties are not significantly different with or without the vanadium.

CHLORATE TREATMENT OF UNBLEACHED PULPS

Marpillero (*3*) recommended treatment of unbleached pulps with "activated" chlorate. Therefore, first an unbleached neutral sulphite semichemical pulp was bleached with 12% ACl on pulp, at 10% consistency, at 70°C., at pH 2.2 for 4 hr. After washing, the pulp was extracted with 4% NaOH on pulp, at 15% consistency, at 60°C., for 2 hr., with end pH 12.0. This was followed by another treatment with 12% ACl under the same conditions as the first stage. The brightness was 28.3%, showing that the pulp was not bleached with even 24% ACl on pulp, which is equivalent to 48% available chlorine.

To show that this pulp was bleachable, it was bleached in three stages (*11*) with: (1) 18% Cl_2 and 0.5% ClO_2, at 3% consistency, at 25°C. for 1 hr; (2) 4% NaOH and 2.0% NaOCl, at 15% consistency, at 60°C., for 2 hr.; (3) 1.5% ClO_2, at 6% consistency, at 70°C., at pH 6, for 3 hr. G.E. brightness 90.5%.

Thus, although this pulp had a relatively high bleach demand, it was bleached to 90.5% G.E. brightness with 24% available chlorine as chlorine and chlorine dioxide, while 48% available chlorine as catalyzed chlorate did not bleach it at all under the conditions used.

CHLORATE STEEP BLEACHING OF UNBLEACHED KRAFT PULP

Unbleached spruce-balsam kraft pulp of high lignin content was treated with 3, 6, and 9% $NaClO_3$ on pulp, with 0.25% V_2O_5 on $NaClO_3$, at 30% consistency, at 23°C., at pH 0.15.

The permanganate number (Fig. 11) dropped slowly with time, indicating that the chlorate was reacting with the lignin in the pulp. With 9% $NaClO_3$ on pulp, in 42 days the permanganate number dropped from 22.3 to 1.7 indicating that most of the reducing power of the pulp had been eliminated.

Three per cent sodium chlorate did not bleach the pulp (Fig. 12). Six per cent raised the brightness to 47% after 10 days, but longer time did not increase it. With 9%, chlorate brightness continued to rise slowly to 71.7% after 42 days.

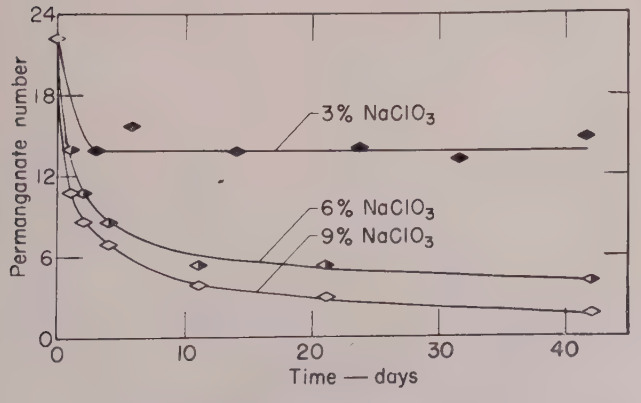

Fig. 12. Chlorate steep bleaching unbleached kraft pulp

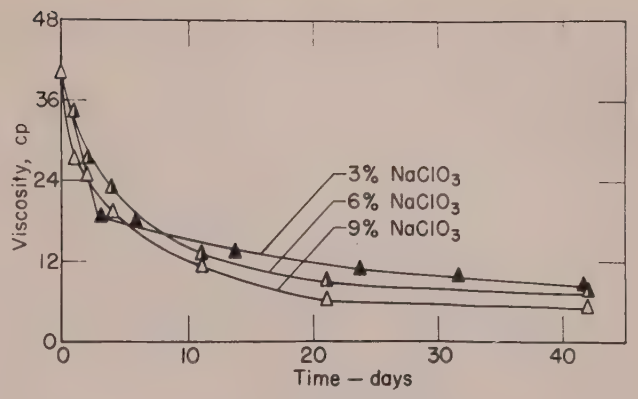

Fig. 13. Chlorate steep bleaching unbleached kraft pulp

The viscosity dropped at a similar rate with all three amounts of chlorate (Fig. 13). With 9% chlorate it dropped from 40 to about 7 cp., indicating very severe damage to pulp strength. With the same amount of chlorate the hot alkali solubility increased from 11.0 to 37.7%, again indicating considerable oxidation and hydrolysis of the carbohydrate components of the pulp (Fig. 14).

The same unbleached pulp was bleached in three stages with 10% Cl_2 + 0.05% ClO_2 on pulp, 2% NaOH + 2% NaOCl, and 2.0% ClO_2 under the conditions described previously (*11*) to 88.1 G.E. brightness with 28.9 cp. viscosity.

Therefore, it must be concluded that while sodium chlorate catalyzed with vanadium pentoxide will bleach unbleached kraft pulp at room temperature, the amount of chlorate required is too great, the reaction is far too slow and too much damage is done to the pulp to compete with standard methods of bleaching.

CHLORATE ADDITION TO CHLORINATION

In 1956 Heitman (*10*) reported that the addition of sodium chlorate along with the chlorine used in the chlorination of unbleached pulps brought about "an increase in yield, strength, and brightness."

Many research laboratories and some mills have tried this with variable results, some finding a slight effect, and some no advantage. Therefore, the addition of chlorate in the chlorination has not been adopted in any mill as far as we are aware.

Experiments were carried out in our laboratory to check this proposal as soon as it was announced. Unbleached western hemlock pulp was chlorinated with 6% Cl_2 on pulp, at 3% consistency, at 25°C., for 1 hr., with amounts of sodium chlorate varied from 0 to 1.1% on pulp. After chlorination all pulps were extracted with 1% NaOH on pulp, at 15% consistency, at 60°C. for 2 hr. After washing, the pulps were treated with 1.2% available Cl_2 as sodium hypochlorite, at 6% consistency, at 35°C., for 3 hr., ending at pH 10 to 10.5. The results are shown in Fig. 15.

Up to 0.5% $NaClO_3$ on pulp added to the chlorination the effect of the chlorate addition was relatively slight. Brightness increased a little, viscosity increased very slightly and yield increased very slightly. However, further increases in chlorate brought about a sharp drop

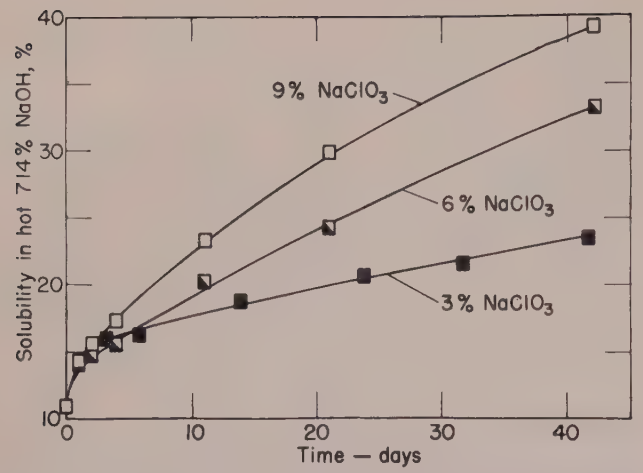

Fig. 14. Chlorate steep bleaching unbleached kraft pulp

in brightness, an increase in viscosity, and a slight increase in yield. These are all evidence of an inhibitory action of the chlorate on the chlorination, i.e., the chlorine is less effective, not attacking the lignin or the cellulose as much as in the absence of chlorate. Several similar experiments not reported here gave similar results, always a lowering of final brightness as the chlorate addition to the chlorination was increased.

Recently, after the work on catalyzed chlorate bleaching had been done, on the suggestion of Hatch (*12*) some more experiments were carried out with sodium chlorate and vanadium pentoxide in the chlorination.

A spruce-jack pine unbleached kraft pulp with a high lignin content was used. Conditions were the same as above for all stages, except that 11% Cl_2 was used in chlorination, and in some cases 0.25% V_2O_5 on $NaClO_3$ was added, and 40°C. was used for the third stage. The results are shown in Table IV.

The vanadium pentoxide caused the brightness to increase with increasing amounts of sodium chlorate instead of decrease as it did without the catalyst. The viscosity rose sharply with 1% $NaClO_3$ without catalyst. With vanadium pentoxide the viscosity rose with a small amount of chlorate, then dropped sharply with larger amounts of chlorate. The hot alkali solubility decreased with small amounts of chlorate with or without catalyst, but increased sharply as larger amounts of catalyzed chlorate were added to the chlorination.

These results indicate that chlorate in the chlorination suppresses the oxidizing action of the chlorine, as suggested by Heitman, but in the presence of vanadium the chlorate becomes a strong oxidizing agent under chlorination conditions. Thus as the amount of catalyzed chlorate increases, the protective action of the chlorate is offset and, although brightness increases, viscosity decreases and hot alkali solubility increases, indicating severe degradation of the pulp.

Therefore, it must be concluded that although the addition of some chlorate to the chlorination, with or without vanadium, may have a slight beneficial effect, the advantage obtained is not large enough to justify the cost of the chlorate. If too much catalyzed chlorate is added, the pulp may be seriously degraded.

Table IV. Chlorate in Chlorination of Unbleached Kraft Pulp

Conditions:
Stage 1: 11% Cl_2 on pulp, with and without $NaClO_3$ on pulp, 3% consistency, 25°C., 1 hr.
Stage 2: 2% NaOH on pulp, 15% cons., 60°C., 2 hr.
Stage 3: 1.2% NaOCl as available Cl_2 on pulp, 6% cons., 40°C., 3 hr., pH 10.5 at end

% $NaClO_3$ on pulp	% V_2O_5 on $NaClO_3$	G.E. brightness, % Before aging	G.E. brightness, % After aging	Hot alkali sol., %	Visc., cp.
0	0	67.3	60.3	22.2	9.2
1.0	0	66.1	59.1	15.5	17.3
0.5	0.25	69.6	61.7	15.7	15.7
1.0	0.25	69.5	62.0	18.9	11.8
2.0	0.25	73.3	65.0	22.1	8.6
5.0	0.25	75.4	66.8	27.3	6.3

EXPERIMENTAL

Except where otherwise noted above, bleaching was carried out in batches of 30 g. of pulp, in 1-qt. sealed fruit jars, under the conditions mentioned, in constant temperature water baths.

Brightness was measured with a Beckman DU spectrophotometer with reflectance attachment, at 457 mμ wavelength, using a magnesium carbonate standard and multiplying the reflectance by 0.98 to convert to G.E. brightness.

Aging was carried out by heating in a circulatory oven at 105°C. for 18 hr.

P.C. (post color) number =

$$\left(\frac{k}{s} \text{ after heating} - \frac{k}{s} \text{ before heating}\right) \times 100$$

where

$$\frac{k}{s} = \frac{(1 - R)^2}{2R}$$

and

k = the absorption coefficient of the sheet
s = the scattering coefficient of the sheet
R = the brightness of a pad of sheets of infinite thickness.

Viscosity was determined in 0.5% concentration in cupriethylenediamine solution by TAPPI Standard T 230 sm-50.

Solubility in hot 7.14% NaOH solution was determined by the method described in (*13*).

SUMMARY

Bleaching directly with sodium chlorate in the absence of a catalyst has been accomplished at a reasonable rate only under conditions of very high acidity which cause severe degradation of the pulp.

Vanadium is a unique positive catalyst for sodium

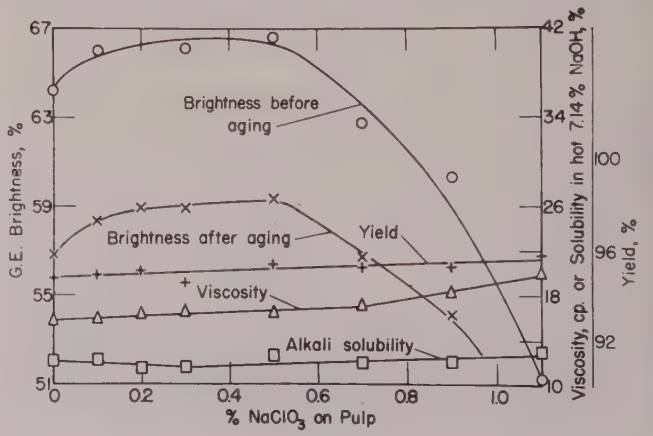

Fig. 15. Chlorate in chlorination

chlorate bleaching, speeding up the reaction and allowing the acidity to be lowered to a range where damage caused by hydrolysis and oxidation may be considered small enough to be acceptable for certain purposes. This damage is still too much, however, where strength is important.

By increasing consistency, lowering the temperature, and prolonging the bleaching time to several days, as recommended by Marpillero (*8*) for "activated chlorate," degradation of the pulp is lessened somewhat relative to the brightness achieved. By prolonging the time to several weeks, very high brightness levels may be reached with vanadium catalyzed chlorate. However, only in very exceptional circumstances could such a long bleaching time be economically tolerated.

This "cold steep" method can be applied to catalyzed chlorate bleaching of unbleached pulps. When bleaching was continued for a long time in order to reach relatively high brightness severe damage was done to the pulp.

The amounts of sodium chlorate required to bleach any of the pulps tested were much larger than the equivalent amounts of the usual bleaching agents. For example, chlorine dioxide bleached pulps to higher brightness with far less than the equivalent of the chlorate, with negligible damage to the pulp. Furthermore, higher temperatures can be used with chlorine dioxide in order to shorten the bleaching time to economical limits without degrading the pulp.

The addition of sodium chlorate to the chlorination stage of pulp bleaching as recommended by Heitman (*10*) was made more effective by adding some vanadium pentoxide to the chlorate. With small amounts of catalyzed sodium chlorate in chlorination, brightness, and viscosity were increased, but with larger amounts viscosity dropped sharply, even though brightness continued to increase.

It is unfortunate that conditions have not yet been found which would make it economically possible to bleach directly with sodium chlorate without degradation of the pulp. While much progress has been made in this direction, better pulp brightness, color stability, and strength can be still obtained by converting the chlorate into chlorine dioxide. Even for pulps of less than the highest quality, direct bleaching with catalyzed sodium chlorate would probably be more costly than with the bleaching chemicals now in use.

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Studies on the Interfiber Bonds of Wood*

III. An Investigation on Hot Stock Pressure Refining of NSSC Pulp

LENNART JANSSON, STIG LAGERGREN, and SVEN RYDHOLM

As the interfiber bonds of wood are weakened by an increase in temperature, hot stock refining is of interest for mechanical and semichemical pulping to decrease power consumption, and possibly to decrease the extent of ruptures across the fiber wall. Extreme hot stock refining under pressure is possible in connection with continuous cooking, and an Asplund Defibrator added to the conventional Kamyr cooking system was tested for this purpose with a subsequent secondary low-temperature refining stage on the pulp blown from the digester, in the production of neutral sulphite semichemical pulp for bleached glassine paper. However, it was soon found out that although the total energy consumption was somewhat reduced, high temperature refining caused an inferior pulp quality, as judged from beating and paper strength testing of unbleached as well as bleached pulps. By increasing the distance between the Defibrator disks, to yield a very coarse pulp, the final pulp quality was only little improved. By lowering the temperature of the refining and digester discharge system, quality was gradually improved to correspond to that of low-temperature refined pulp. The phenomena, which bear close resemblance to those observed in continuous kraft cooking, are interpreted as a chemical attack of the cooking liquor on the exposed secondary wall, when the transition lamella is damaged or loosened by mechanical action. However, as no effects on the analytical composition of the pulps could be observed, the chemical action is believed to influence the quality rather than the quantity of the strength-bearing components.

Previous studies (*1*, *2*) have disclosed that the strength of the interfiber bonds decrease on (1) temperature increase, (2) swelling in water by chemicals, especially alkali, and (3) delignification. Mechanical rupture occurs across the fiber walls to a large extent when subjecting unswollen wood to stress at low temperature, whereas after swelling or at high temperature the rupture increasingly occurs between the transition lamella and the main part of the secondary wall. On partially delignified wood, mechanical action also leads to separation of the fibers at the middle lamella, to an extent increasing with the degree of delignification. Whereas, on pulping, rupture across the fiber walls

Lennart Jansson, AB Kamyr, Karlstad, Sweden; Stig Lagergren, Billeruds AB, Säffle, present address Stora Kopparbergs Bergslags AB, Skutskär, Sweden, and Sven Rydholm, Billeruds AB, Säffle, Sweden.

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Table I. Effect of Plate Setting on Quality of Bleached Pulp

Pressure refining at 162°C.

	Place setting, mm. 0.3	2.0	5.0
Paper characteristics			
Valley beating to 45° S.-R.			
Beating time, min.	10	11	7
Tensile strength, km.	7.4	7.8	8.0
Bursting strength	61	64	66
Tearing strength	58	57	57
Sheet density, g./cc.	0.84	0.86	0.84
Opacity	185	160	170
Valley beating to porosity 10 cc./sec.			
Beating time, min.	19	21	15
Slowness, °S.-R.	73	69	74
Tensile strength, km.	7.9	8.2	8.2
Bursting strength	64	66	67
Tearing strength	48	46	48
Sheet density, g./cc.	0.98	0.98	0.99
Opacity	97	92	85
Roe chlorine no. of unbleached pulp	15.5	15.2	15.9

must necessarily cause a low-quality pulp, a separation of the fibers involving destruction of the transition lamella cannot *a priori* be assumed to be disadvantageous. Therefore, fiberizing at high temperature could possibly be of benefit by decreasing the amount of ruptures across the fiber walls and increase the ruptures at the transition lamella. Furthermore, as the fiberizing energy consumption will decrease on increasing the temperature, hot stock refining has long been preferred to cold stock refining in semichemical pulping. Generally, such refining is carried out at about 60 to 80°C., especially where batch cooking is practised. However, continuous cooking offers possibilities of refining at digester temperature, where the lignin of the middle lamella shows thermoplastic flow. The classical example hereof is the Defibrator system, which produces a mechanical pulp by steam heating wood chips to 170 to 190°C. and subsequent fiberizing in a disk refiner under full pressure. Also, continuous semichemical pulping systems have employed the same system of fiberizing. There are, however, few if any indications in the literature as to the influence of pressure refining on pulp quality.

For the special case of pulp production for bleached greaseproof and glassine papers, Billeruds AB has em-

Table II. Effect of Refining Temperature on Quality of Bleached Pulp

Refiner plate setting 5.0 mm.

	Refining temperature, °C. 162	130	120	110
Paper Characteristics				
Valley beating to 45° S.-R.				
Beating time, min.	7	9	15	9
Tensile strength, km.	8.0	8.6	8.9	9.6
Bursting strength	66	73	76	80
Tearing strength	57	62	61	68
Sheet density, g./cc.	0.84	0.88	0.81	...
Opacity	170	160	140	130
Valley beating to porosity 10 cc./sec.				
Beating time, min.	15	15	23	13
Slowness, °S.-R.	74	68	61	61
Tensile strength, km.	8.2	8.8	9.2	10.2
Bursting strength	67	77	78	83
Tearing strength	48	51	55	61
Sheet density, g./cc.	0.99	0.99	0.87	...
Opacity	85	92	92	91

Table III. Effect of Refining Temperature on Analytical Data on Unbleached Pulp

	Refining temperature, °C. 162	130	120	110
Refiner plate setting 5.0 mm.				
Roe chlorine no.	15.9	14.2	15.2	14.4
Pentosan content, %	22.6	24.2	24.2	21.1
R_{18}, %[a]	88.0	86.7	86.9	86.6
R_{10}, %[a]	83.4	79.8	81.8	81.1
$1/2(R_{18} + R_{10})$; %[b]	85.7	83.3	84.4	83.8

[a] Insoluble fractions in 18 and 10% NaOH, determined after chlorite delignification.
[b] Approximately equal to alpha-cellulose content.

ployed a system which is shown in Fig. 1. Birch chips are cooked in the Kamyr continuous digester by the neutral sulphite process, sodium base, and the soft chips are refined in a Defibrator prior to discharge to a blow tank, a Davenport press, and a secondary Sprout-Waldron refining. The refined pulp is screened and then bleached in a conventional three-stage C-E-H sequence. The present paper will deal with the quality problems encountered with this system, and particularly with the effect of pressure refining at various plate settings and various temperatures, as compared to low-temperature refining.

EXPERIMENTAL

Cooking and Bleaching

The pulp was prepared from birch chips consisting of a technical mixture of *Betula pubescens* and *Betula verrucosa*. Cooking was performed in the Kamyr continuous digester by the neutral sulphite process at a maximum temperature of about 165°C. and 3.5 hr. in the cooking zone. The amount of cooking chemicals added was kept constant to give an unbleached yield of about 72% of the wood, at a Roe chlorine number of about 15. The final pH of cooking liquor was kept at 7.0 to 7.5. In order to regulate the bottom temperature of the digester, cold water was introduced in the bottom circulation in controlled quantities.

After refining, the pulp was bleached either in the laboratory or in the continuous mill bleaching plant according to the sequence chlorination-alkaline extraction-hypochlorite bleaching. The amount of chlorine and hypochlorite added was varied after the Roe chlorine number to give a brightness of about 80% G.E., and this resulted in a final bleached yield of 57 to 60% of the wood at a Roe chlorine number of 15 in the unbleached pulp.

Sampling

The variables studied were:

1. Effect of defibrator plate setting on strength quality of bleached pulp.
2. Effect of refining temperature on strength quality of bleached and unbleached pulp.

Table IV. Effect of Refining Temperature on Analytical Data on Bleached Pulp

	Refining temperature, °C. 162	130	120	110
Refiner plate setting 5.0 mm.				
Pentosan content, %	27.6	28.1	28.1	25.6
R_{18}, %	89.4	89.0	90.1	89.0
R_{10}, %	84.5	84.6	85.7	84.6
$1/2(R_{18} + R_{10})$, %	87.0	86.8	87.9	86.8

Table V. Effect of Refining Temperature and Plate Setting on Quality of Bleached Pulp

Samples removed from A, Digester bottom above bottom scraper; B, Discharge pipe immediately prior to defibrator; C, Press after defibrator; and D, Filter after refiner.

Refining temperature, °C. →	*110*	*110*	*110*	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*	*150*	*150*
Plate setting, mm. →	*5.0*	*5.0*	*5.0*	*5.0*	*0.3*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*	*∞t*	*∞t*
Place of sampling →	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*A*	*C*	*A*	*C*	*A*	*C*
						Paper characteristics							
Valley beating to 45°S.-R.													
Beating time, min.	5	6	7	9	4	6	3	6	6	4	5	4	10
Tensile strength, km.	9.0	9.4	9.4	9.6	9.2	9.2	8.9	8.9	8.8	9.0	8.2	9.2	8.6
Bursting strength, km.	78	80	81	80	78	80	78	74	73	78	68	77	71
Tearing strength, km.	71	72	69	68	68	66	69	68	63	67	60	73	65
Opacity	148	138	134	130	133	125	147	135	122	135	145	145	150
Valley beating to porosity, 10 cc./sec.													
Beating time, min.	11	10	12	13	9	10	9	9	9	9	10	10	16
Slowness, °S.-R.	68	65	66	61	62	61	67	...	...	...	...	...	60
Tensile strength, cm.	9.7	9.9	9.7	10.0	9.5	9.3	9.7	9.2	9.1	9.3	8.6	9.4	9.2
Bursting strength, cm.	84	85	82	83	82	82	81	76	74	80	70	78	75
Tearing strength, cm.	60	63	62	61	62	59	60	64	58	59	53	66	59
Opacity	91	90	81	91	80	80	87	73	85	87	93	90	110
Roe chlorine no. of unbl. pulp	14.7	13.7	14.4	14.6	14.1	12.9	14.5	12.4	13.9	13.4	13.5	12.1	11.0

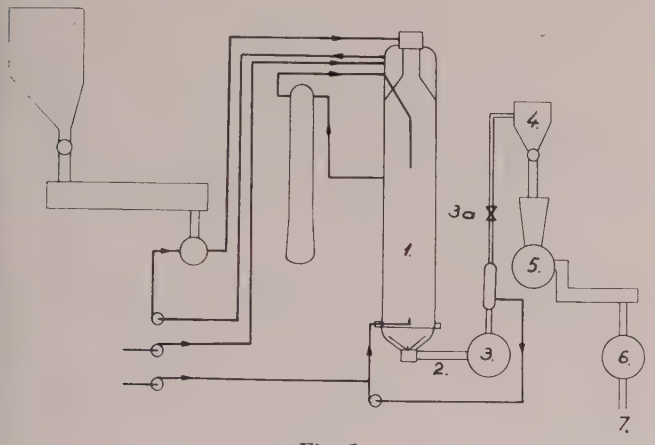

Fig. 1

3. Effect of other mechanical treatment of pulp in the bottom of the digester on strength quality.

In order to investigate the first two of these points, samples of unbleached pulp were taken from the filter after the refiner (see Fig. 1). These samples were then bleached in the laboratory according to the same scheme as in the mill bleaching plant. Under the same fiberizing conditions mill bleached samples were also taken from the filter after the hypochlorite bleaching tower.

In order to investigate the third point, and to get strength values for mill cooked and laboratory refined pulp, samples were taken from the digester bottom above bottom scraper (see Fig. 1), from the discharge pipe immediately prior to the defibrator and also from the press after the defibrator. These samples were withdrawn with a special sampling device, constructed by AB Kamyr (*3*), as shown in Fig. 2. The sampling device consists of a pressure vessel joined to the digester by a ball valve, and equipped with connection pipes for pressure air and water, and in the bottom with a valve for taking out the sample. The working principle is to balance the digester pressure with pressure air when the ball valve to the digester is opened, and then carefully release the air pressure from the sampling device in order to withdraw soft chips from the digester. In the sampling device the chips fall into cold water, and are then emptied through the bottom valve.

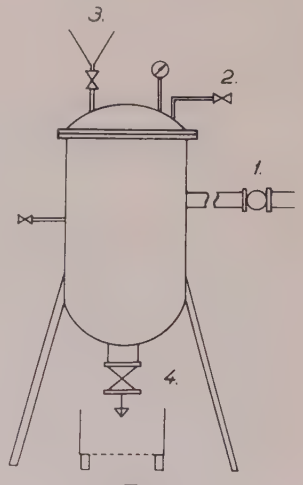

Fig. 2

Under the same fiberizing conditions several

Table VI. Effect of Refining Temperature and Plate Setting on Quality of Unbleached Pulp

Samples removed from A: Digester bottom above bottom scraper; C: Press after defibrator

Refining temperature, °C.	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*
Plate setting, mm. →	*5.0*	*5.0*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*
Place of sampling →	*A*	*C*	*A*	*C*	*A*	*C*	*A*	*C*
				Paper characteristics				
Valley beating to 45° S.-R.								
Beating time, min.	4		5		3	3	4	5
Tensile strength, km.	7.5		7.5		7.1	6.3	6.5	6.5
Bursting strength	56		57		53	44	49	48
Tearing strength	61		62		68	60	63	54
Opacity	110		170		170	200	185	160
Valley beating to porosity, 10 cc./sec.	15	19	20	16	15	16	19	15
Beating time, min.								
Slowness, ° S.-R.	78	~90	...	~90	90	91	84	81
Tensile strength, km.	8.5	8.4	8.6	8.7	8.4	8.3	8.2	7.6
Bursting strength	62	63	64	65	65	63	59	58
Tearing strength	51	49	51	52	49	46	49	46
Opacity	110	65	120	85	75	75	90	75
Roe chlorine no.	12.0	13.2	12.0	13.8	11.5	13.6	13.2	13.2

Table VII. Effect of Refining Temperature and Plate Setting on Flat Crush Resistance of Unbleached Pulp

Samples removed from A: Digester bottom above bottom scraper; C: Press after defibrator

Refining temperature, °C.	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*	*Average*	
Plate setting, mm. →	*5.0*	*5.0*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*		
Place of sampling	*A*	*C*	*A*	*C*	*A*	*C*	*A*	*C*	*A*	*C*
CMT (lb.) after refining to 20°S.-R.	63.0	54.3	64.7	60.4	68.4	64.3	59.4	58.2	64	59
Roe chlorine no.	14.7	14.8	14.1	14.5	13.2	14.2	13.5	13.7	13.9	14.3

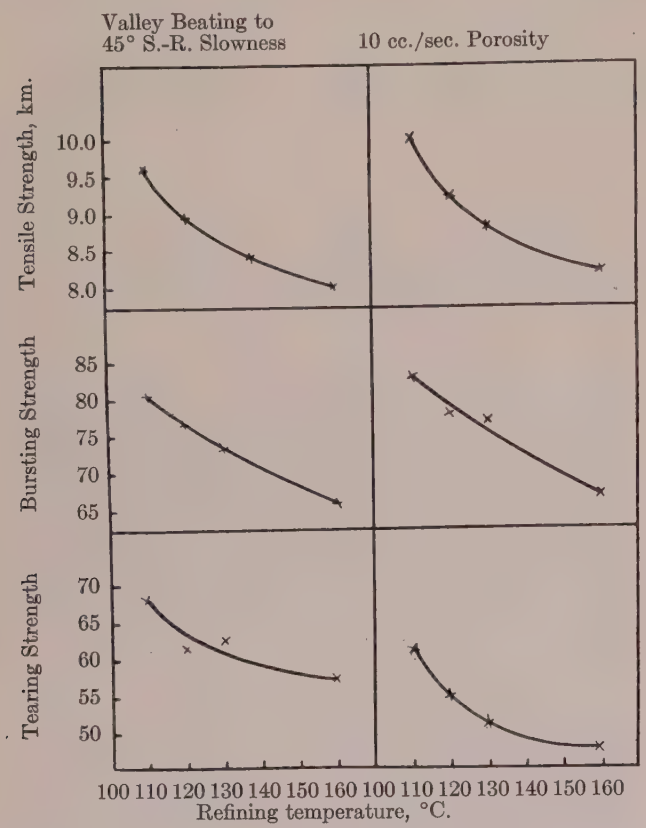

Fig. 3

series of samples were taken in each place mentioned to give mean values for different properties. The strength properties are judged after beating in a Valley hollander according to TAPPI Standard T 200 m-34 with a load of 6 kg., and drying the sheets between blotters at 60°C. after pressing for 2 min. at 5.4 kp per sq. cm. The testing was carried out according to Swedish Standard CCA 17 for tensile, bursting, and tearing strength, as well as paper density, opacity, and air porosity by the Billerud instrument, and the results were compared at 45°S.-R. slowness as well as at a standard air porosity of 10 cc. per sec. The unbleached pulps were also tested for crushing resistance according to the Concora test (ASTM D 1225–54).

RESULTS AND DISCUSSION

It was quite soon realized after the initial troubles of the mill start-up that the pulp quality was inferior to that obtained in batch trial cooks, although the energy consumption of refining seemed to be quite low. In order to investigate the influence of the Defibrator plate setting, the latter was increased from the ordinary 0.3 mm. to 2.0 and finally 5.0 mm. These changes caused the pulp leaving the pressure system to be very coarse, as a matter of fact some soft chips passed relatively unaffected through the Defibrator. As shown by Table I and Fig. 3, the quality of the final bleached pulp was only slightly improved (most figures represent average values of several tests, the pulp obtained under the initial refining conditions being tested every day over a month).

It was therefore concluded that if the damage was caused by pressure refining, the effect was not purely a mechanical one but probably also of a chemical nature and in analogy to what had been successfully tried in the Kamyr kraft digesters, the bottom temperature

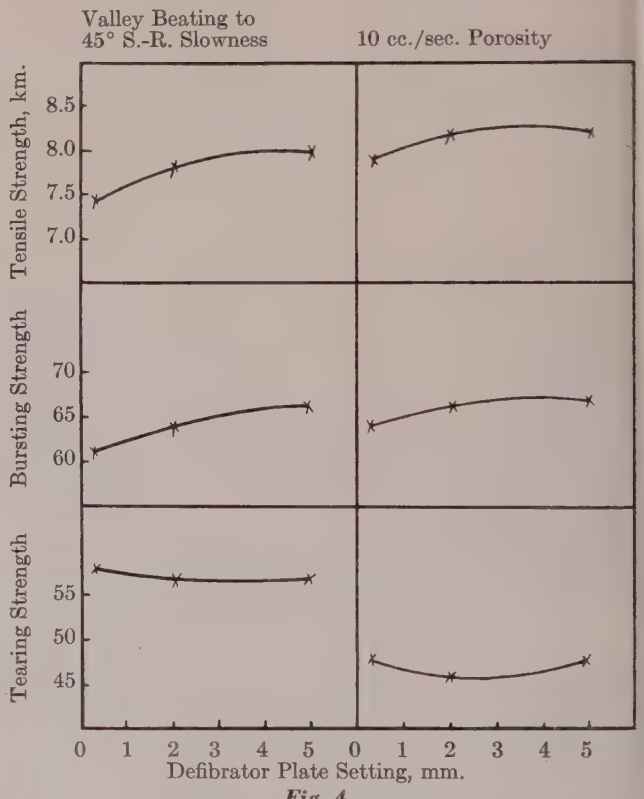

Fig. 4

Table VIII. Effect of Refining Temperature and Plate Setting on Quality of Bleached Pulp

Summary of results obtained on Valley beating to porosity 10 cc./sec. Samples removed from A: Digester bottom; C: Press after defibrator

Refining temperature, °C.	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*	*160*
Plate setting, mm. →	*5.0*	*5.0*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*	*0.3*
Place of sampling →	*A*	*C*	*A*	*C*	*A*	*C*	*A*	*C*	*C*
Beating time, min.	11	12	9	9	9	9	9	10	19
Tensile strength, km.	9.7	9.7	9.5	9.7	9.2	9.1	9.3	8.6	7.9
Bursting strength	84	82	82	81	76	74	80	70	64
Tearing strength	60	62	62	60	64	58	59	53	48
Product of tensile and tear	580	600	590	580	590	530	550	460	380
Product of burst and tear	5040	5090	5090	4860	4860	4290	4720	3710	3070

Table IX. Effect of Refining Temperature and Plate Setting on the Analytical Composition of Unbleached and Bleached Pulps (of Table V)

Refining temperature, °C. →	*110*	*110*	*110*	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*	*150*	*150*
Plate setting, mm. →	*5.0*	*5.0*	*5.0*	*5.0*	*0.3*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*	*∞*	
Place of sampling →	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*A*	*C*	*A*	*C*	*A*	*C*
						Analytical composition							
Unbleached pulp													
Roe chlorine no.	14.7	13.7	14.4	14.6	14.1	12.9	14.5	12.4	13.9	13.4	13.5	12.1	11.0
Pentosan content, %	21.7	20.9	21.6	21.4	25.4	24.5	25.2	24.3	24.7	23.4	24.6	22.1	21.7
R_{18}, %[a]	85.9	86.4	86.2	86.4	84.6	84.3	83.7	84.2	85.2	85.0	86.1	86.7	...
R_{10}, %[a]	80.8	81.4	81.1	81.5	79.4	79.9	78.5	79.3	79.5	78.8	80.8	81.9	...
$1/2(R_{18} + R_{10})$, %[b]	83.4	83.9	83.7	84.0	82.0	82.1	81.1	82.1	82.4	81.9	83.5	84.3	...
Resin content, %	0.98	1.08	1.07	1.16	0.68	0.92	0.63	0.92	0.94	0.94	0.89	0.87	1.36
Bleached pulp													
Brightness, % G.E.	77.0	78.0	80.2	80.5	72.7	75.5	73.4	78.0	78.4	79.1	81.7	80.2	84.1
Pentosan content, %	26.2	26.5	25.6	26.1	27.8	28.6	28.5	28.3	27.7	30.4	29.7	27.1	27.1
R_{18}, %	89.6	89.0	89.0	87.8	87.8	87.8	88.2	89.2	88.9	88.7	88.8	87.7	87.8
R_{10}, %	85.1	85.2	84.2	85.7	84.3	83.9	85.2	85.6	86.0	85.8	85.7	85.3	84.8
$1/2(R_{18} + R_{10})$, %	87.4	87.1	86.6	87.8	86.1	85.8	86.7	87.4	87.5	87.3	87.3	86.5	86.3
Resin content, %	0.42	0.52	0.50	0.56	0.46	0.45	0.28	0.46	0.40	0.27	0.29	0.41	0.79
Yield of bleaching, %	83.7	84.0	84.0	84.4	83.6	83.1	83.6	85.2	85.2	83.9	84.8	86.9	87.2

[a] Insoluble fractions in 18 and 10% NaOH, determined after chlorite delignification.
[b] Approximately equal to alpha-cellulose content.

of the digester was lowered (*4*). The results are given in Table II and Fig. 4. It is clearly seen that a considerable improvement was obtained which far exceeded the effect of increasing the refining disk gap. In comparison to the pulp originally obtained, the quality had been improved by 27% in tensile strength, 30% in bursting strength, and 27% in tearing strength. This effect should possibly be reflected in the chemical analysis of the corresponding pulps. However, as judged from the conventional analysis figures given in Tables III and IV, no such differences could be found. The slight variations obtained are probably caused by changes in the cooking conditions.

The investigation was now extended to sampling in the bottom of the digester with the special sampling device described in the experimental part. In this way undefibrated soft chips were withdrawn from the digester for comparison with the pulp which had passed the Defibrator but not the Sprout-Waldron refiner. In the first series of samples at the lowest bottom temperature, soft chips from the outlet pipe immediately prior to the refiner were likewise sampled, to judge the effect of the bottom scraper of the digester. All samples were refined in the laboratory refiner, in contrast to the pulps dealt with hitherto and for comparison also Sprout-Waldron mill-refined pulp was sampled and tested after bleaching in the laboratory as far as the rest of the samples. The results are shown in Table V as average values of consecutive series taken under identical refining conditions. Obviously, at 110°C. and 5.0 mm. plate setting, no detrimental action is exerted by the Defibrator, nor by the discharge machinery. The slightly higher strength of mill refined pulp indicates somewhat superior refining than that carried out in the laboratory. In the subsequent series only laboratory-refined pulp was tested.

Table V reveals further that even at tighter plate setting, no decrease in the pulp quality is obtained at 110°C., which is additional evidence that the damage observed at higher temperature is of a chemical nature, although produced by mechanical action. The results from higher temperature substantiate this conclusion, as the wider plate setting at 130°C., and especially 160°C., shows considerable damage to the pulp. Even by bypassing the Defibrator, substantial damage is obtained at higher temperature, due to the mechanical action of the discharge machinery. Table VI shows that also the properties of unbleached semichemical pulp are damaged on high temperature refining, although the effect is less pronounced. However, unbleached semichemical pulp is generally used for purposes where the conventional strength characteristics are of less importance. The corresponding pulps were therefore also tested for stiffness in the Con-

Table X. Effect of Refining Temperature and Plate Setting on the Analytical Composition of Unbleached Pulps (of Table VI)

Refining temperature, °C. →	*110*	*110*	*110*	*110*	*130*	*130*	*160*	*160*
Plate setting, mm. →	*5.0*	*5.0*	*0.3*	*0.3*	*5.0*	*5.0*	*5.0*	*5.0*
Place of sampling →	*A*	*C*	*A*	*C*	*A*	*C*	*A*	*C*
				Analytical composition				
Pulp								
Roe chlorine no.	12.0	13.2	12.0	13.8	11.5	13.6	13.2	13.2
Pentosan content, %	23.1	24.8	24.4	23.6	23.8	24.4	23.4	22.6
R_{18}, %	85.8	85.9	85.4	82.5	84.8	85.2	84.7	85.7
R_{10}, %	80.6	79.7	79.2	74.4	79.4	79.2	78.2	80.5
$1/2(R_{18} + R_{10})$, %	83.2	82.8	82.5	78.5	82.1	82.2	81.3	83.1
Uronic acid anhydride, %	1.79	1.79	2.10	2.04	2.15	2.29	1.87	2.06
Carbohydrates								
Glucose, %	71.0	69.8	68.5	66.4	70.8	69.9	69.2	69.4
Mannose, %	1.5	1.9	3.5	3.3	3.6	2.6	2.4	2.6
Xylose, %	27.5	28.4	28.0	30.3	25.7	27.5	28.4	28.0
Fraction soluble in 10% NaOH								
Glucose, %	5.4	5.6	5.7	...	4.3	5.1	5.5	5.4
Mannose, %	4.4	5.6	7.6	...	5.1	6.0	3.7	4.2
Xylose, %	90.2	88.8	86.8	...	90.6	89.0	90.8	90.4

cora test for corrugated board. The results, given in Table VII, indicate that the quality is decreased by pressure refining, but to a lesser extent than the ordinary strength characteristic of bleached pulp, and in a manner which seems to be little influenced by the bottom temperature. However, as the variations in the values were comparatively great, the results may not be quite significant statistically. In any case, it can be concluded that the properties of the unbleached pulp is much less affected by the refining conditions. Table VIII summarizes the results. It is indicated that the degree of cooking also will influence the strength properties to some extent, causing a drop in strength of some of the samples taken out of the digester with a Roe number somewhat lower than normal.

To investigate the chemical effect on the pulp during the refining at high temperature, analyses were carried out on both unbleached and bleached pulps of the above-mentioned series, Tables IX and X. Not only the conventional analysis figures, but also the result of a chromatographic investigation are presented. As before, however, the differences observed are small and must entirely be ascribed to variations in the mill cooking conditions. The conclusion is therefore that the chemical effect does not cause any appreciable changes in the analytical composition of the pulp but is probably connected with changes in the D.P. of some of the carbohydrate fractions.

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An Investigation of the Sulphonic Acids Derived from Xylose and Arabinose

RICHARD H. CORDINGLY

Identical sulphonic acids were formed from D-xylose and L-arabinose upon treatment with hot sodium sulphite-bisulphite solutions at pH 6.3 to 6.6. The crude acids separated into six spots on paper chromatograms. Treatment with animal charcoal-celite mixtures removed approximately one half of the materials in the crude acids. The resulting products, termed the decolorized sugar-sulphonic acids, analyzed as $C_5H_{10}O_7S$ and were chromatographically homogeneous using two developers. Approximately 4 atoms of oxygen were consumed and 1.67 moles of carbon dioxide were evolved per $C_5H_{10}O_7S$ unit upon oxidation of the decolorized acids with chromic acid. Sulphosuccinic, and α- and β-sulphopropionic acids were oxidation products. Approximately 0.59 mole of oxidant was consumed and 0.07 mole of formaldehyde was evolved per $C_5H_{10}O_7S$ unit upon oxidation of the decolorized acids with periodate. An acidic aldehyde of undetermined structure was a product of this reaction. The decolorized sugar-sulphonic acids were separated via their brucine salts into two fractions. One of these fractions may have been identical with the xylosulphonic acid shown to have the structure of an α,δ-dihydroxy-γ-sulphovaleric acid by Yllner, *Acta Chem. Scand.* 10: 1251–1257 (1956).

THE spent liquors produced in acid and neutral sulphite pulping processes have been extensively investigated with regard to their nature and composition. Because of their potential economic value, the decomposition of carbohydrates in such liquors has received considerable attention; however, the possible transformation of carbohydrates into sulphonated products has not been thoroughly investigated.

The first evidence that sulphonated carbohydrates may be formed during acid sulphite pulping of wood was presented by Erdtman (*1*). The acidic components in a spent liquor were divided into four fractions according to their average molecular weight as follows: (1) higher molecular weight acids precipitated with 4–4′-bis—dimethylaminodiphenylmethane sulphate; (2) high molecular weight acids obtained by an incomplete precipitation with brucine; (3) low molecular weight acids obtained by completing the precipitation with brucine; and (4) lower molecular weight acids obtained by precipitation of their barium salts in ethanol. Fractions (1) and (2) were lignosulphonic acids; but fractions (3) and (4) contained materials which probably were "carbohydrate sulphonic acids or joined with such acids with the formation of glucosides." Subsequently, other investigations by Erdtman, Ericson, and Hägglund (*2*); Samuelson (*3*); and Heiwinkel (*4*) have supported Erdtman's conclusion.

These sulphonated carbohydrates which may be present in spent pulping liquors have not been thoroughly investigated. In attempting to obtain pure products, Adler (*5*) and Hägglund, Heiwinkel, and Bergek (*6*) treated holocellulose preparations with hot, acid sulphite liquors. However, the products still were contaminated, mainly with aldonic acids. The effect of acid and neutral sulphite solutions on lactose and cellobiose was investigated by Heiwinkel (*4*), but no sulphur-bearing products were isolated.

Adler (*5*) and Hägglund, Johnson, and Urban (*7*) found that glucose was converted into the corresponding aldonic acid in acid sulphite liquors, but Hägglund and co-workers (*7, 8*) showed that fructose yielded a sulphonic acid of undetermined structure under the same conditions. A sulphonated product, tentatively identified as "levoglucosan-6-sulphonic acid," was prepared by Matsui (*9, 10*) from glucose by the action of a bi-

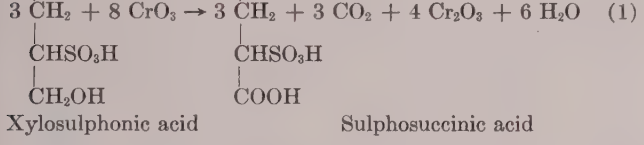
RICHARD H. CORDINGLY, Graduate Student, The Institute of Paper Chemistry, Appleton, Wis.; present address, Weyerhaeuser Timber Co., Longview, Wash. Work performed at The Institute of Paper Chemistry.

sulphite solution. Adler (*5*) and Hägglund and co-workers (*7*) have studied the sulphonic acids derived from glucose upon treatment with a hot, nearly neutral (pH 6) sodium sulphite-bisulphite solution. One acid, which analyzed as $C_6H_{10}O_8S$ and which was isolated via its water-insoluble phenylhydrazone, contained an aldehyde, a carboxyl, a sulphonic acid, and a terminal glycol group. Another gluco-sulphonic acid, which analyzed as $C_6H_{12}O_8S$, was also isolated. This acid contained a carboxyl, a sulphonic acid, and a terminal glycol group. The structure of these acids has not been fully established.

Yllner (*11*) studied the sulphonic acids prepared from xylose upon treatment with a hot, nearly neutral (pH 6.5) sodium sulphite-bisulphite liquor. The crude acids, which were isolated in about 50% yield, were shown to be sulphocarboxylic acids.

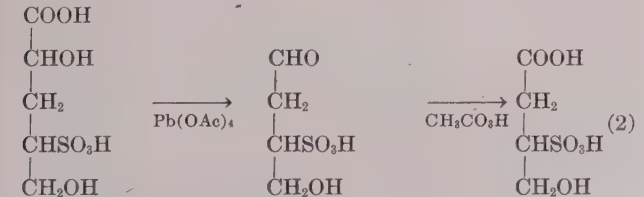
The crude acids were decolorized with animal charcoal-celite (1:1), and then were separated into two fractions via the brucine salts. One fraction, composed of rod-shaped crystals, was isolated in approximately 50% yield on the basis of the initial charcoal-purified acids. The second fraction, which had needle-shaped crystals, was isolated in a yield of about 25%, but was not investigated further.

The rod-shaped brucine salt was converted into the barium salt which crystallized readily from water-ethanol mixtures. The barium salt was optically inactive and analyzed as $C_5H_8O_7SBa \cdot H_2O$. Since the acid did not possess any reducing properties, Yllner assigned the oxygen not found in the sulphonic and carboxylic acid functions to two alcohol groups. Chromic acid oxidation indicated that one alcohol group was primary. The consumption of oxidant was approximately equal to that theoretically required to produce sulphosuccinic acid according to the hypothetical reaction shown in equation (1) (2.67 moles CrO_3 or 4 atoms of oxygen per mole of xylosulphonic acid). No attempt to isolate the sulphosuccinic acid was reported.



Xylosulphonic acid — Sulphosuccinic acid

The structure of the pure xylosulphonic acid was shown to be that of an α,δ-dihydroxy-γ-sulphovaleric acid by subjecting it to the sequence of reactions shown in equation (2). The resulting sulphobutyric acid was identified as β-sulpho-γ-hydroxybutyric acid by comparing the properties of its pyridinium salt with those of the authentic material.



Xylosulphonic acid — β-Sulpho-γ-hydroxybutyric acid

EXPERIMENTAL

Crude Xylo- and Arabosulphonic Acids

The sulphonic acids were prepared from D-xylose and L-arabinose by the general procedure of Adler (*5*) and Hägglund and co-workers (*7*). A mixture of 10 g. of sugar, 15 g. of $NaHSO_3$, and 20 g. of Na_2SO_3 were dissolved in sufficient water to make a solution of 200 ml. The initial pH of the liquor ranged from 6.3 to 6.6. The liquor was heated in a stainless steel autoclave to 130°C. in $2^1/_2$ hr. and maintained at that temperature for 1 additional hour.

After cooling, the light yellow-colored liquor was treated with 12 ml. of conc. H_2SO_4 and concentrated at 60°C. under reduced pressure until sodium sulphate began to crystallize. A volume of 25 ml. of 95% ethanol was added, and the resulting mixture was placed in the refrigerator overnight to precipitate more of the sodium sulphate. After removing these salts by filtration, the liquor was diluted to 200 ml. and passed through a column of Amberlite IR-120* cation-exchange resin in the acid form to remove the remaining sodium ions.

The barium salts were prepared by treating the acid effluent with excess barium carbonate at 80 to 90°C. After removing barium sulphate and excess barium carbonate by filtration, the filtrate was concentrated at 60°C. under reduced pressure. The concentrate was poured into 95% ethanol to precipitate the barium sugar-sulphonates. The yields of crude salts were 46.5 and 47.2% (calculated as $C_5H_8O_7SBa \cdot H_2O$) on the basis of the starting xylose and arabinose, respectively.

The crude products were optically inactive as either the barium salts or the free acids, and did not contain a reducing carbonyl group as shown by their inactivity toward phenylhydrazine and Tollens reagent (*12*). The free acids were oxidized by periodic acid (*12*). (Calculated for $C_5H_8O_7SBa \cdot H_2O$: Ba 37.4, S 8.72.) Found: Crude barium xylosulphonate; Ba 37.8, S 9.40. Crude barium arabosulphonate; Ba 37.3, S 9.48.

Chromatographic Studies

The crude xylo- and arabosulphonic acids exhibited identical chromatographic properties in the various systems employed in this study. Initially, the crude, free acids were converted into the anilide derivatives and studied according to a paper chromatographic procedure of Green (*13*). The chromatograms were developed for 44 hr. with: (a) ethyl acetate-acetic acid-formic acid-water (18:3:1:4) (EAFW) (*14*); (b) *n*-butanol-acetic acid-water (63:10:27) (BAW) (*14*); and (c) *iso*butyric acid saturated with water (iBW) (*15*). After their development, the chromatograms were air dried and sprayed with an acetone solution of Rhodamine B dye. Inspection of the sprayed chromatograms under ultraviolet light showed the anilides as dark areas against a light background.

In order to facilitate the identification of sulphur-bearing compounds, a sample of the arabosulphonic acids tagged with sulphur-35** was converted into the anilides and chromatographed. The location of sulphur-bearing compounds on the chromatograms was established by noting the radioactive areas with a thin-window G-M counter.

* A product of the Rohm and Haas Co.

** Sulphur-35 introduced by adding 100 microcuries of radioactive sulphur as sodium bisulphite in 100 microliters of water to a $^1/_{40}$ scale cook of arabinose. The cook was conducted in a glass tube.

The sulphur-bearing compounds moved very slowly in the above developers and were not cleanly separated. As a very general observation, however, four sulphur-containing spots were discernible.

The free sugar-sulphonic acids were chromatographed on Whatman no. 1 paper with the developers, (a) *n*-propanol-95% ethanol-1.6*N*-ammonium carbonate (10:60:30) (PEAm) (*16*) and (b) 95% ethanol-concentrated ammonium hydroxide (100:1) (EAm) (*17*). Development required 24 hr. using PEAm and 72 hr. using EAm. After their development, the sheets were air dried. The chromatograms were sprayed with 4% formaldehyde and dried at 105°C. to convert the ammonium salts to urotropine and the free acids as suggested by van Duuren (*16*). The acids were then detected as red spots against a yellow-orange background by spraying with a 0.1% aqueous solution of methyl orange.

Using either developer PEAm or EAm, four acid spots were discernible. Using PEAm, these spots had R_f values of 0.35, 0.49, 0.58, and 0.64 and were termed acids 1, 2, 3, and 4, respectively. R_f values could not be assigned using developer EAm since the solvent ran off the bottom of the sheets; but the spots were termed acids 1′, 2′, 3′, and 4′ in the order of increasing distance from the origin.

In the preliminary phases of this work, arabosulphonic acids tagged with sulphur-35 were chromatographed to facilitate the identification of sulphur-containing materials. Acids 1 and 1′ were very rich in sulphur; acids 2 and 2′ also contained significant quantities; but acids 3 and 4, and 3′ and 4′ contained much less than the others.

When the crude sugar-sulphonic acids were chromatographed on Whatman 3MM paper using developer EAm for 72 hr., the spot previously termed 3′ separated into three spots. Thus, in this chromatographic system, the crude acids separated into a total of six acidic spots, termed 1′, 2′, 3′a, 3′b, 3′c, and 4′. The relationship between the acid spots as found in the various chromatographic systems is shown diagrammatically in Fig. 1.

Since spot 2′ was one of the more important sulphur-bearing spots, it was eluted from several chromatograms

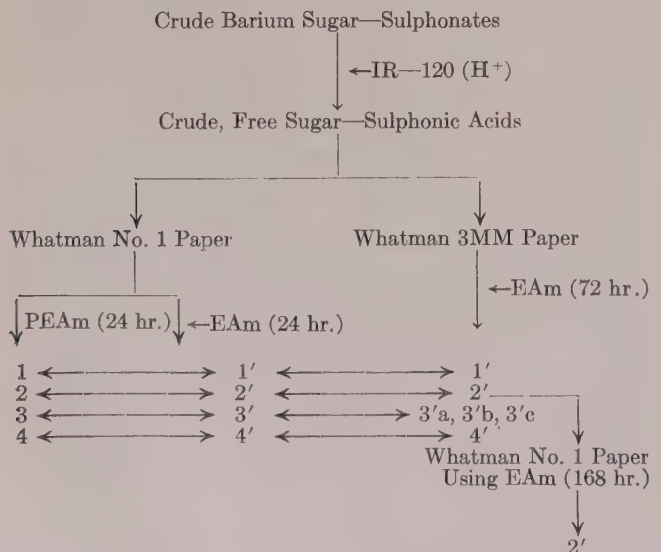


Fig. 1. Chromatographic studies of the crude, free sugar-sulphonic acids

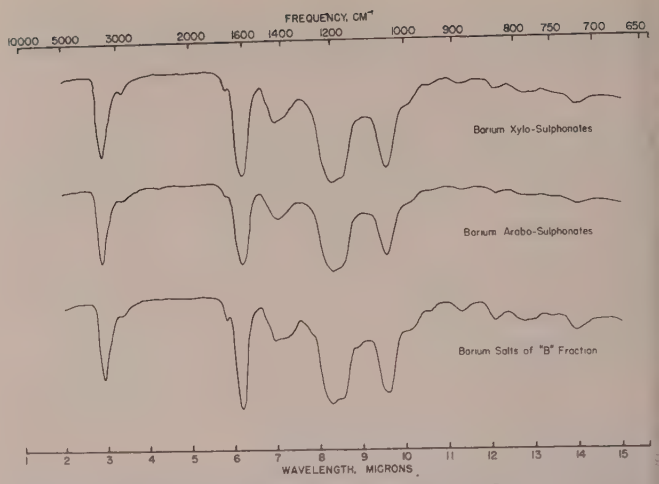

FREQUENCY, CM⁻¹
10000 5000 3000 2000 1600 1400 1200 1000 900 800 750 700 650
Barium Xylo-Sulphonates
Barium Arabo-Sulphonates
Barium Salts of "B" Fraction
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
WAVELENGTH, MICRONS

Fig. 2. Infrared spectra of the decolorized barium sugar-sulphonates and of the barium salts of the "B" fraction.

and rechromatographed. This material remained chromatographically homogeneous.

Decolorized Xylo- and Arabosulphonic Acids

The decolorized barium sugar-sulphonates were prepared in yields of from 50 to 60% by treating the crude products with animal charcoal-Celite* according to the general procedure of Yllner (*11*). The resulting salts were noncrystalline and optically inactive. Elemental analysis indicated that the decolorized barium sugar-sulphonates had the composition $C_5H_8O_7SBa \cdot H_2O$ as shown in Table I. The infrared spectra were identical as shown in Fig. 2 indicating that the acids were identical materials whether originally derived from D-xylose or L-arabinose. Paper chromatograms of the free xylo- and arabosulphonic acids using developers PEAm and EAm were identical. Only one acid spot, corresponding to spot 2 or 2′ of the crude acids, was found, thus indicating that the materials were chromatographically homogeneous.

Fractionation via the Brucine Salts

Two fractions of the decolorized xylo- and arabosulphonic acids were isolated as the brucine salts according to the general procedure of Yllner (*11*). The first crystalline products were recrystallized twice from water-acetone mixtures. The resulting substances, which were colorless and rod-shaped crystals, were termed the "A" fractions of brucine salts. The yields were 20.7 and 16.2% on the basis of the decolorized xylo- and arabosulphonic acids, respectively. The optical activities were $[\alpha]_D^{24.8} = -26.4 \pm 0.2°$ (*c* 4.92, 2 dm. tube, water) and $[\alpha]_D^{25.0} = -26.1 \pm 0.2°$ (*c* 4.97, 2 dm. tube, water), respectively. The ultraviolet spectra of the two salts were identical and had transmittance maxima at 236 and

* A product of the Johns-Manville Co.

Table I. Decolorized Barium Xylo- and Arabosulphonates

Component	*Calculated for $C_5H_8O_7SBa \cdot H_2O$, %*	*Found*	
		Xylo-acid salt, %	*Arabo-acid salt, %*
Ba	37.4	37.5	37.6
S	8.73	9.08	8.85
C	16.4	16.1	16.3
H	2.18	2.46	2.48
H_2O	4.90	4.97	4.90

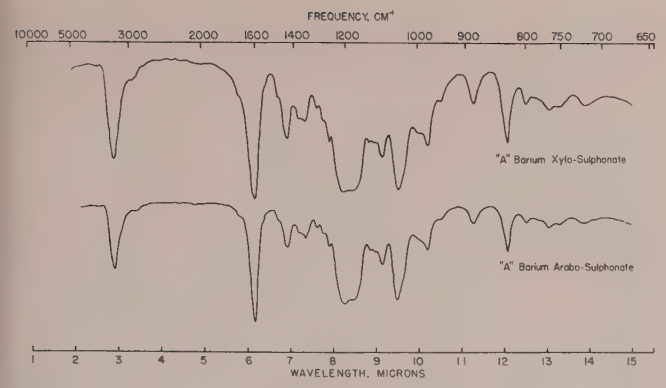

FREQUENCY, CM⁻¹
10000 5000 3000 2000 1600 1400 1200 1000 900 800 750 700 650
"A" Barium Xylo-Sulphonate
"A" Barium Arabo-Sulphonate
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
WAVELENGTH, MICRONS

Fig. 3. Infrared spectra of the "A" barium sugar-sulphonates.

285 mμ and minima at 263 and 300 mμ. In addition, the infrared spectra were identical.

Since the above data, together with the information which was obtained on the decolorized products, indicated that the xylo- and arabosulphonic acids were identical substances, the mother liquors from the "A" fraction brucine salts were combined and subjected to further fractional crystallization. A second modification of the brucine salts, termed the "B" fraction, was obtained in a yield of 0.89% on the basis of the initial decolorized sugar-sulphonic acids. The "B" fraction brucine salts were needle-shaped and had a specific rotation of $[\alpha]_D^{24.6} = -36.0 \pm 0.8°$ (*c* 3.04, 2 dm. tube, water).

The "A" and "B" brucine salts were converted into the barium salts. The "A" barium salts crystallized from water-ethanol mixtures in yields of 24.2 and 31.1% on the basis of the brucine salts or 5.04 and 5.03% on the basis of the initial decolorized xylo- and arabosulphonic acids, respectively. The barium salt of the "B" fraction could not be crystallized and was, therefore, isolated by precipitation in ethanol in a yield of 65.5% based on the brucine salt or 0.59% based on the initial decolorized sugar-sulphonic acids.

The "A" acids were optically inactive as either the barium salts or the free acids. When the free acids were chromatographed on Whatman no. 1 paper using developers PEAm or EAm, only one acidic spot, corresponding to spot 2 or 2′, respectively, of the crude acid mixtures, was found. The infrared spectra of the "A" barium xylo- and arabosulphonates were identical as shown in Fig. 3. The free acids were stable toward periodate.

The optical activity of the barium salt of the "B" fraction was $[\alpha]_D^{24.0} = -23.1 \pm 0.6°$ (*c* 1.74, 2 dm. tube, water), and its infrared spectrum was similar to that of the decolorized barium sugar-sulphonates as shown in Fig. 2. The free acid was slowly oxidized by periodate indicating the presence of a 1,2-glycol group (0.307 mole periodate consumed per mole of "B" acid, calculated as $C_5H_{10}O_7S$, in 72 hr.). The consumption of oxidant was followed iodometrically. A qualitative test with chromotropic acid indicated that formaldehyde was one of the oxidation products (*18*).

The chemical analyses of the "A" fractions are given in Table II. The "B" fraction, however, was not analyzed.

Chromic Acid Oxidations

The fractionation studies indicated that the decolorized xylo- and arabosulphonic acids were mixtures. The elemental analyses showed, however, that both the decolorized and the "A" acids had the composition $C_5H_{10}O_7S$. Furthermore, the data indicated that the "A" acids and the pure xylosulphonic acid studied by Yllner (*11*) were identical substances, and, therefore, probably had the structure of an α, δ-dihydroxy-γ-sulphovaleric acid.

Table II. Analyses of the "A" Acids as the Brucine and Barium Salts

			Found	
	Component	*Calculated value, %*	*Xylo-acid salt, %*	*Arabo-acid salt, %*
Brucine salt	S	3.20	3.08	3.06
$C_5H_{10}O_7S \cdot 2C_{23}H_{26}O_4N_2$	OCH_3	12.4	12.2	12.0
	Brucine	79.0	76.5	75.8
Barium salt	Ba	37.4	37.8	37.6
$C_5H_8O_7SBa \cdot H_2O$	S	8.72	8.35	8.46

Chromic acid oxidation was used by Yllner as a part of the investigations to determine the structure of his pure xylosulphonic acid. The hypothetical reaction is given in equation (1). In this study, chromic acid oxidation was used in an attempt to obtain more information concerning the composition and nature of the decolorized xylo- and arabosulphonic acids.

In the initial work, the decolorized acids were oxidized with chromic acid using essentially the same reaction conditions employed by Yllner as shown in Table III. The consumption of oxidant was found to be approximately 4 atoms of oxygen per $C_5H_{10}O_7S$ unit. This value was in accord with Yllner's hypothetical reaction of α,δ-dihydroxy-γ-sulphovaleric acid yielding sulphosuccinic acid as shown in equation (1). However, approximately 1.5 moles of carbon dioxide were evolved instead of the theoretical 1 mole per $C_5H_{10}O_7S$ unit. In addition, little or no sulphosuccinic acid was isolated from the oxidation liquors.

Authentic sulphosuccinic acid prepared by the method of Backer and van der Zanden (*19*) was stable toward the oxidizing medium. By modifying the oxidation conditions as shown in Table III and by studying the isolation procedure using facsimiles of the oxidation liquors containing known amounts of authentic sulphosuccinic acid, a technique was developed whereby a 50% recovery of the sulphosuccinic acid could be consistently effected.

Upon applying these modified oxidation conditions to the decolorized xylo- and arabosulphonic acids, approximately 4 atoms of oxygen (4.04 and 3.96 atoms respectively) were consumed and 1.67 moles of carbon dioxide (1.69 and 1.66 moles, respectively) were evolved per $C_5H_{10}O_7S$ unit.

Application of the recovery procedure resulted in the isolation of sulphosuccinic and α- and β-sulphopropionic acids as oxidation products. Upon completion of the

Table III. Chromic Acid Oxidation Reaction Conditions

	Original conditions (11)		*Modified conditions*	
Component	*Weight, g.*	*Molar ratio*	*Weight, g.*	*Molar ratio*
Sugar-sulphonic acid	0.0975	1	0.585	1
$K_2Cr_2O_7$	0.50	11.2 (as [0])[a]	3.0	11.2 (as [0])[a]
H_2SO_4	4.41	100	5.35	20

Volume of solution made up to 50 ml. with water.
[a] Calculated from the following equations:
$K_2Cr_2O_7 \rightleftharpoons K_2O \cdot 2CrO_3$
$2CrO_3 \rightarrow Cr_2O_3 + 3\ [0]$

oxidation, the excess oxidant was destroyed by adding formaldehyde. A slight excess of ammonium hydroxide was then added to precipitate chromic hydroxide which was removed by filtration. After passing the filtrate through a column of Amberlite IR-120 resin in the acid form, sodium hydroxide was added until the solution was neutral. The solution was taken to dryness, and the sodium salts were extracted with 80% ethanol for 24 hr. The extract, containing α- and β-sulphopropionates, was converted into the free acids and chromatographed on Whatman 3MM paper for 48 hr. using EAm developer. Four acidic materials were located on the paper sheets by means of guide strips. The four components were eluted from the paper sheets and converted into the barium salts. Two components were shown to be the barium salts of α- and β-sulphopropionic acids; the other two materials were not identified. Identification of the barium sulphopropionates was made by comparing their infrared spectra to those of authentic barium α-sulphopropionate prepared by the method of Backer and Dubský (*20*) and barium β-sulphopropionate prepared according to Kharasch, Chao, and Brown (*21*). In addition, the S-benzyl-*iso*-thiourea salt of the β-isomer was prepared according to the method of Schenck and Danishefsky (*22*) and found to melt at 151 to 152°C.* Its melting point was not depressed when mixed with the salt of the authentic acid. The yields of α-sulphopropionic acid were 2.9 and 2.6%, and those of the β-isomer were 3.1 and 3.7% based on the total conversion of the decolorized xylo- and arabosulphonic acids, respectively, into these substances.

Sulphosuccinic acid was isolated from the residual sodium salts of the 80% ethanol extraction. The salts were acidified with hydrochloric acid equivalent to the maximum theoretical yield of sulphosuccinic acid (1 mole per $C_5H_{10}O_7S$ unit). Ethanol was added to the acidified mixture to precipitate the insoluble inorganic sodium salts. After filtering, the alcoholic filtrate was treated with a small quantity of barium chloride and filtered to remove the precipitated barium sulphate. After neutralizing the filtrate with potassium hydroxide, barium chloride was added to form the insoluble barium salt of sulphosuccinic acid. This product was identified by comparing its infrared spectrum to that of the authentic material and by elemental analysis. The yields were 12.3 and 14.7% based on the total conversion of the decolorized xylo- and arabosulphonic acids, respectively, into this product.

Periodic Acid Oxidation

An amount of 1.2 g. ($^1/_3$ mole fraction) of the decolorized xylo- or arabosulphonic acids was slowly oxidized by 2.16 g. ($^2/_3$ mole fraction) of periodic acid in 100 ml. of solution at room temperature and in the absence of light. The consumption of oxidant, which was followed iodometrically, was found to be 0.59 mole per $C_5H_{10}O_7S$ unit. An attempt was made to follow the evolution of aldehydes by alkaline hypoiodite oxidation (*23*). However, when the decolorized sugar-sulphonic acids alone were subjected to alkaline hypoiodite oxidation, it was found that extensive oxidation occurred (1.49 mole hypoiodite consumed per $C_5H_{10}O_7S$ unit). Hence, it was apparent that this reaction was not suitable for following the evolution of aldehydes during the periodic acid oxidations.

The periodic acid oxidation was repeated, and in addition to following the consumption of oxidant, the evolution of formaldehyde was determined colorimetrically with chromotropic acid according to the method of Mitchell and Percival (*24*) and gravimetrically as formaldehyde dimethone using the technique of Reeves (*25*). The amount of formaldehyde evolved was found by the colorimetric method to be approximately 0.15 mole per mole of periodic acid consumed and 0.12 mole per mole by the gravimetric procedure. In the case of the latter procedure, the crystalline product melted at 187 to 189°C., and its melting point was not depressed when mixed with an authentic sample of formaldehyde dimethone.

Another oxidation product was isolated as follows: an aliquot of the reaction liquor was neutralized with barium hydroxide to precipitate the insoluble barium periodate and iodate salts. After filtering, the liquor was poured into 95% ethanol to precipitate the water-soluble barium salts, and thereby separate them from the formaldehyde. The solids were removed by filtration, washed with absolute ethanol and ether, and dried at 60°C. under reduced pressure over phosphorus pentoxide. An aqueous solution of the barium salts formed a precipitate with 2,4-dinitrophenylhydrazine and reacted with Tollens reagent (*12*) indicating the presence of an aldehyde group.

DISCUSSION

The optical inactivity of the crude xylo- and arabosulphonic acids indicated that the asymmetric centers of the starting sugars had been randomized during the preparative reaction. This information, together with the data which showed that the xylo- and arabosulphonic acids were identical materials, indicated that all pentose sugars would yield identical sulphonic acids under the conditions employed in this work. Chromatographic studies showed that the crude acids were mixtures of at least six substances. All this information is in general agreement with Adler's (*5*) hypothesis that the sugar-sulphonic acids may be formed in a manner analogous to that of the saccharinic acids.

The decolorized sugar-sulphonic acids, which analyzed as sulphocarboxylic acids with the composition $C_5H_{10}O_7S$, were chromatographically homogeneous using PEAm and EAm developers. Fractional crystallization of their brucine salts indicated, however, that they were mixtures. One component has many properties in common with the pure xylosulphonic acid shown by Yllner (*11*) to have the structure of an α,δ-dihydroxy-γ-sulphovaleric acid.

Approximately 4 atoms of oxygen were consumed per $C_5H_{10}O_7S$ unit during chromic acid oxidations of the decolorized sugar-sulphonic acids. These data were in accord with the hypothetical conversion of α,δ-dihydroxy-γ-sulphovaleric acid into sulphosuccinic acid as shown in equation (1). However, 1.67 moles of carbon dioxide were evolved instead of the theoretical one mole per $C_5H_{10}O_7S$ unit. As a result, a deliberate search was conducted for oxidation products of lower carbon content than sulphosuccinic acid, and, in addition to sulphosuccinic acid, α- and β-sulphopropionic acids were found.

* Melting points uncorrected.

The periodate oxidations further established the fact that the decolorized sugar-sulphonic acids were mixtures. These data indicated that at least three types of compounds were present.

CONCLUSIONS

The following conclusions may be drawn concerning the sulphonic acids prepared in this work from D-xylose and L-arabinose according to the general procedure of Adler (*5*) and Hägglund and co-workers (*7*):

1. The asymmetric centers of the starting sugars were randomized during the reaction producing the crude xylo- and arabosulphonic acids as shown by the optical inactivity of the resulting products.

2. The crude xylo- and arabosulphonic acids were shown to be sulphocarboxylic acids by elemental analysis of their barium salts. The barium-to-sulphur ratios were 0.92 and 0.94 for the xylo- and arabosulphonates, respectively. A pure barium sulphocarboxylic acid salt theoretically would have a barium-to-sulphur ratio of 1.00.

3. The chromatographic properties of the crude xylo- and arabosulphonic acids were identical indicating that the acids probably were identical materials.

4. The crude xylo- and arabosulphonic acids were shown to be mixtures of at least six components since, when chromatographed on paper using EAm developer, six acidic spots were found.

5. The crude xylo- and arabosulphonic acids were at least partially purified by treatment with animal charcoal-Celite mixtures since the resulting products were chromatographically homogeneous in PEAm and EAm developers.

6. The decolorized barium xylo- and arabosulphonates analyzed as $C_5H_8O_7SBa \cdot H_2O$. Since the barium-to-sulphur ratios were 0.97 and 0.99 for the xylo- and arabosulphonates, respectively, the acids were sulphocarboxylic acids.

7. The decolorized xylo- and arabosulphonic acids did not contain aldehyde or ketone groups as shown by their inactivity toward phenylhydrazine and Tollens reagent (*12*). As a result, the oxygen not found in the sulphonic and carboxylic acid functions was tentatively assigned to two hydroxyl groups.

8. The infrared spectra of the decolorized barium xylo- and arabosulphonates were identical showing that the acids themselves were identical materials.

9. During the course of chromic acid oxidations of the decolorized xylo- and arabosulphonic acids, approximately 4 atoms of oxygen were consumed and 1.67 moles of carbon dioxide were evolved per $C_5H_{10}O_7S$ unit. In addition, sulphosuccinic, and α- and β-sulphopropionic acids were shown to be oxidation products. These data tend to further substantiate the hypothesis that the two sugar-sulphonic acids were identical materials.

10. The decolorized xylo- and arabosulphonic acids were shown to be mixtures of at least three types of compounds by periodic acid oxidation. These types may be classified as follows: (a) Approximately 41% of the decolorized acids consisted of materials which did not contain any 1,2-glycol groups as shown by their stability toward periodate. (b) Approximately 7% of the decolorized acids consisted of materials containing terminal 1,2-glycol groups as shown by the quantity of formaldehyde evolved during the reaction. (c) Approximately 52% of the decolorized acids consisted of materials containing 1,2-glycol groups which were nonterminal.

Besides the formaldehyde, an unidentified acidic aldehyde was shown to be an oxidation product. Thus, the original 1,2-glycol must have contained a secondary rather than a tertiary alcohol.

11. The "A" sulphocarboxylic acids derived from xylose and arabinose were shown to be identical substances by chemical analyses, infrared spectra, and specific rotations of their crystalline brucine and barium salts. In addition, the ultraviolet spectra of the brucine salts of the "A" xylo- and arabosulphonic acids were identical.

12. The "A" xylo- and arabosulphonic acids probably were composed of *d,l* pairs of stereoisomers since they were optically inactive.

13. The "A" xylo- and arabosulphonic acids did not contain any 1,2-glycol groups as shown by their stability toward periodate.

14. The "A" xylo- and arabosulphonic acids had many properties in common with the pure xylosulphonic acid shown by Yllner (*11*) to have the structure of an α,δ-dihydroxy-γ-sulphovaleric acid.

15. The "B" fraction of the sugar-sulphonic acids may be a mixture as indicated by its behavior upon treatment with periodate and the somewhat indefinite nature of its infrared spectrum.

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The Distribution of Oxidant Consumption in Bleaching

J. H. E. HERBST and H. KRÄSSIG

In the degradation of cellulose, the function $1/P_j - 1/P_o$, where P_j and P_o are the degrees of polymerization at time j and at the start, respectively, is approximately proportional to the fraction of bonds broken. Plots of this function against the amount of bleach consumed were studied for various pulps. All plots comprised straight portions. The intercept of the straight portion with the abscissa (the axis along which the bleach consumption was plotted) was found to increase with increasing residual lignin content. The slope of the straight portion was found to decrease with increasing residual lignin content and with increasing hemicellulose content. The content of alcohol-benzene-soluble matter had no effect on the intercept and slope. The effect of several other variables on the intercept and slope was investigated.

When oxidizing agents react with wood pulp, several reactions (oxidation of residual lignin, chain scission, oxidation of functional groups) are known to occur. Paulson (*1*), investigating the reaction of sulphate pulps with hypochlorite, measured the change in pulp fluidity with hypochlorite consumption ($d\phi/dt$) and found that, in delignified pulps, $d\phi/dt$ was constant, while, in pulps containing lignin, a period in which hypochlorite was consumed mainly by lignin preceded the period during which $d\phi/dt$ was constant. The present paper deals with the graph obtained when the amount of oxidizing agent consumed is plotted against the function $1/P_j - 1/P_o$, where P_o and P_j are the degrees of polymerization initially and at time j. $1/P_j - 1/P_o$ is reasonably proportional to the number of bonds broken in the cellulose chain (cf. Appendix 1).

It was found that, when the amount of oxidizing agent consumed was plotted on the abscissa and $1/P_j - 1/P_o$ on the ordinate, the curve generally had the following shape (typical curves are shown in Fig. 1). At the beginning of the reaction, the curve is horizontal or has a low slope, indicating that the molecular weight drops relatively slowly while the oxidizing agent is being consumed relatively quickly. Later, the slope increases, and finally the curve becomes straight, indicating that in this region the number of bonds broken per unit of oxidizing agent consumed is constant. Two parameters of the straight portion are of interest: the intercept with the abscissa (the axis along which the amount of oxidizing agent is plotted) and the slope. The intercept is the amount of oxidizing agent consumed without bond breaking, and the slope is the efficiency of bond breaking.

The work described in this paper was performed to determine the significance of the intercept and slope and to investigate the factors affecting them. Experimental details are given in Appendix 2.

J. H. E. Herbst, Industrial Cellulose Research Ltd., and H. Krässig, Manager, Basic Research Div., Industrial Cellulose Research Ltd., Hawkesbury, Ont.

RESULTS

1. *Effect of Residual Lignin*

a. Different Pulps. The intercepts and slopes of four pulps known to differ greatly in composition were determined by the standard method (Appendix 2); the results, indicating that the intercept increases and the slope decreases with decreasing purity of the pulp, are shown in Fig. 1 and Table I.

Table I. Different Pulps

Type of pulp	*Intercept, % av. Cl on pulp*	*Slope,* $\frac{P^{-1}}{\%\ Cl} \times 10^3$
Cotton linters	0	1.82
Bleached softwood sulphite viscose pulp	0	1.58
Semibleached (chlorinated and treated with hot alkali) hardwood-softwood sulphite pulp	0.90	0.51
Unbleached hardwood-softwood sulphite pulp	2.40	0.18

b. Different Lots of the Same Pulp. Seven lots of unbleached sulphite pulp made from a mixture of softwoods and hardwoods were subjected to the following tests: determination of intercept and slope by the standard method, permanganate number (*2*), lignin content (*3*), alcohol-benzene-soluble matter (*4*), and Roe number (*5*). The results are listed in Table II.

Regression analysis of these data yielded the following information.

1. The intercept and the slope are linearly related

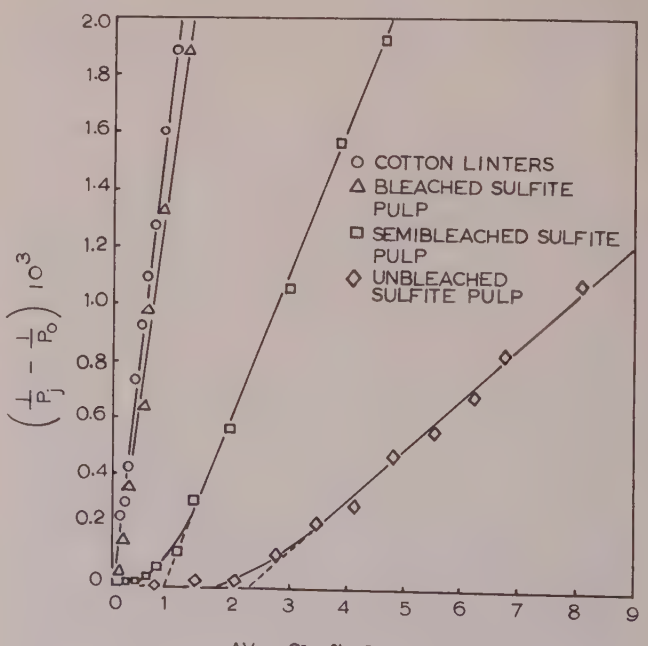

Fig. 1. Different pulps

to the permanganate number, the lignin content, and the Roe number.

2. There is no demonstrable effect of the content of alcohol-benzene-soluble matter on the intercept or slope.

c. Delignification with Chlorine Dioxide. An unbleached softwood sulphite pulp was treated with varying amounts of chlorine dioxide, and the intercepts and slopes characteristic of these pulps were determined by hypochlorite bleaches in the standard manner. The results show that, as the amount of chlorine dioxide added increases, the intercept decreases and the slope increases (cf. Table III and Fig. 2).

Table II. Different Lots of the Same Pulp

Pulp no.	Intercept, % av. Cl on pulp	Slope, $\frac{P^{-1}}{\%\ Cl} \times 10^3$	Permanganate no.	Lignin, %	EtOH-C_6H_6-Sol. matter, %	Roe no.
1	1.78	0.198	5.4	0.88	1.07	1.91
2	2.50	0.151	7.7	1.30	0.85	2.39
3	2.83	0.149	7.9	1.47	0.79	2.55
4	2.67	0.191	6.8	1.31	0.98	2.21
5	2.39	0.180	7.3	1.35	0.98	2.28
6	2.17	0.176	6.5	1.11	0.88	2.28
7	2.72	0.162	8.1	...	1.00	2.49

d. Effect of Chlorination. Samples of a sulphite pulp made from a mixture of softwoods and hardwoods were chlorinated with varying amounts of available chlorine,

Table III. Delignification with Chlorine Dioxide

ClO_2, % on pulp	Intercept, % av. Cl on pulp	Slope, $\frac{P^{-1}}{\%\ Cl} \times 10^3$
0	2.77	0.09
0.8	0.61	0.18
1.3	0.55	0.29
3.0	0.17	0.40
Excess	0.22	0.43

given a hot alkali treatment, and subjected to the standard procedure for the determination of the intercept and slope. Results showing that the intercept decreases and the slope increases with increasing chlorine addition are given in Table IV.

Table IV. Effect of Chlorination

Av. Cl, % on pulp	Intercept, % av. Cl on pulp	Slope, $\frac{P^{-1}}{\%\ Cl} \times 10^3$
2.9	0.78	0.18
3.6	0.52	0.22
4.4	0.24	0.25

e. Addition of Ligninsulphonate. As is shown in Table V, the addition of 6.0% (on pulp) of sodium ligninsulphonate to an unbleached softwood sulphite pulp, which had been treated with an excess of chlorine dioxide, increased the intercept and decreased the slope.

Table V. Addition of Sodium Ligninsulphonate

NaLS, % on pulp	Intercept, % av. Cl on pulp	Slope, $\frac{P^{-1}}{\%\ Cl} \times 10^3$
0	0.22	0.43
6.0	4.83	0.09

These findings show that both the slope and the intercept are functions of the amount of residual lignin; the intercept increases and the slope decreases as the amount of residual lignin increases.

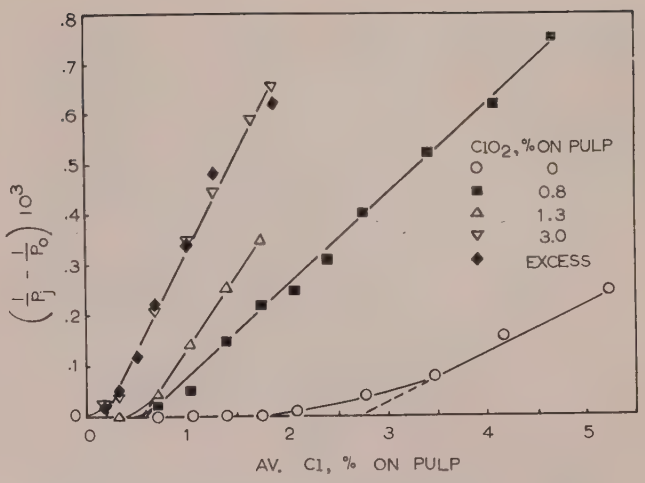

Fig. 2. Delignification with chlorine dioxide

2. *Effect of Bleaching Agent and Temperature*

Figure 3 shows a curve relating to a standard hypochlorite bleach (60°), a curve relating to a hypochlorite bleach performed at 25°, and a curve relating to a peroxide bleach.*

All bleaches were performed on the same unbleached softwood sulphite pulp. Table VI lists pertinent results. It is seen that the intercept is the same for the three curves, and that the slope in the hypochlorite bleaches is only slightly affected by the temperature. The slope is lower with peroxide than with hypochlorite.

Table VI. Effect of Bleaching Agent and Temperature

Type of bleach	Intercept, % av. Cl on pulp	Slope, $\frac{P^{-1}}{\%\ Cl} \times 10^3$
NaOCl, 60°	2.7	0.09
NaOCl, 25°	2.6	0.11
Na_2O_2	2.5	0.04

3. *Effect of Rate of Reaction and pH*

Experiments were performed in which the rate of bleaching was reduced by the gradual addition of the sodium hypochlorite to the reaction mixture at such a rate that the amount of available chlorine present at any time remained constant. The pulp was a softwood

* All peroxide concentrations are given as per cent of available chlorine, based on pulp.

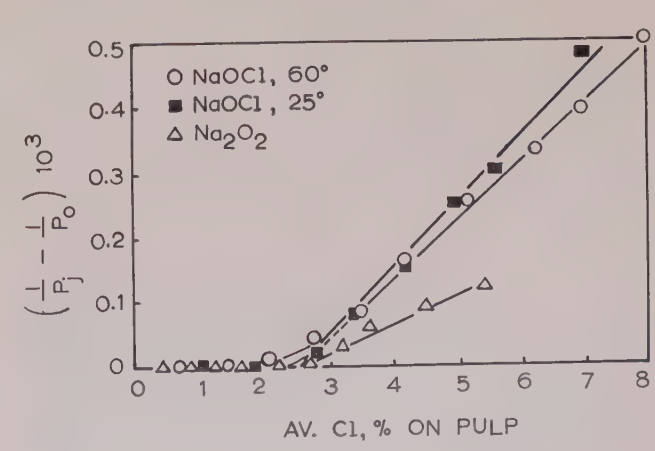

Fig. 3. Effect of bleaching agent and temperature

sulphite pulp which had been chlorinated and treated with hot sodium hydroxide. The experiments were performed with solutions adjusted to three different pH values. It was found that, under all conditions of rate of reaction and pH, the intercept remained constant at 0.89% of available chlorine on pulp. The slope varied as shown in Table VII, decreasing with decreasing rate of reaction and increasing pH.

Table VII. Effect of Rate of Reaction and pH

(The figures in the body of the table are slopes, $\frac{P^{-1}}{\%\ Cl} \times 10^3$)

pH	*Rate of reaction* — *Standard*	*Slow*
9.5–10	0.43	0.32
10.5–11	0.34	0.25
11.5–12	0.22	0.08

4. Effect of Hemicellulose

The hemicellulose content of a softwood sulphite pulp which had been treated with an excess of chlorine dioxide was varied by treatment with sodium hydroxide solution, or by the addition of hemicellulose. The results are listed in Table VIII.

Table VIII. Effect of Hemicellulose Content

Treatment	*Yield, %*	*Intercept, % av. Cl on pulp*	*Slope,* $\frac{P^{-1}}{\%\ Cl} \times 10^3$
4% NaOH on pulp at 95°	98	0	0.67
2% NaOH on pulp at 95°	91	0	0.61
None	100	0.2	0.43
10% Hemicellulose on pulp	...	0	0.27

These data show that the intercept is not affected by the hemicellulose content, and that the slope decreases with increasing hemicellulose content.

5. Effect of Drying

The effect of drying on the slope and intercept is shown in Fig. 4 and Table IX.

An unbleached softwood sulphite pulp and a highly purified bleached acetate softwood sulphite pulp were used. The results show that drying increased the slope for the unbleached pulp but did not affect the intercept; the slope for the bleached pulp was not affected by drying.

Table IX. Effect of Drying

Pulp	*Treatment*	*Intercept, % av. Cl on pulp*	*Slope,* $\frac{P^{-1}}{\%\ Cl} \times 10^3$
Unbleached	Never dried	2.6	0.11
	Dried	2.9	0.21
Bleached	Never dried	0	2.13
	Dried	0	2.14

DISCUSSION

Among the several competing reactions which take place when a pulp reacts with an oxidizing agent, two are of particular interest to us: reaction with the residual lignin and reaction with the cellulose in such a way that the degree of polymerization is reduced (bond breaking). The experimental results presented in section 1 (Effect of Residual Lignin) show that, as the amount of residual lignin increases, the intercept increases and the slope decreases. This suggests that the residual lignin in pulp contains two structures (not necessarily located in different molecules): a "highly reactive" structure which reacts quickly with the oxidizing agent, and a "less reactive" structure which

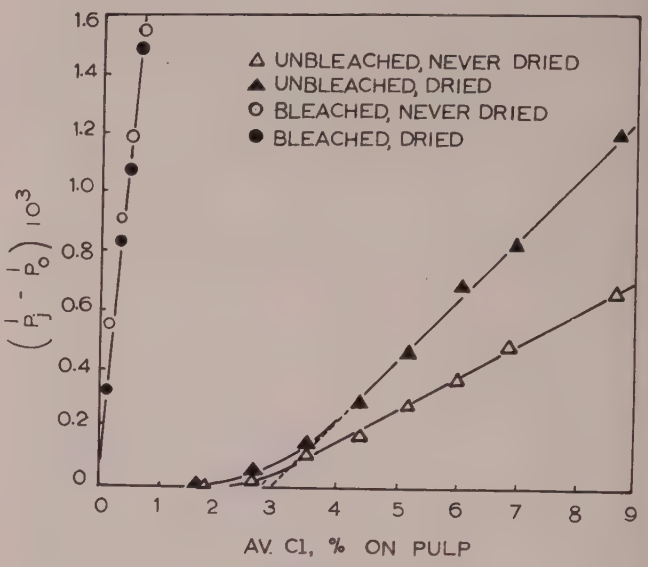

Fig. 4. Effect of drying

reacts at a slower rate. This hypothesis is strengthened by the work of Richtzenhain and Alfredsson (*6*), who also noted two stages in the oxidation of lignin and, with the aid of model compound investigations, attributed the difference in rate to the existence of different structures in the lignin molecule. Thus, during the first stage, in which the curve is almost horizontal, reaction with the highly reactive lignin structure predominates, and the amount of bond breaking is insignificant. As the reaction proceeds and the highly reactive lignin structure is being consumed, bond breaking and reaction with the less reactive lignin fraction become dominant, and the curve becomes straight. Thus the intercept (the amount of bleach consumed without bond breaking) increases with increasing amounts of highly reactive residual lignin, while the slope (the efficiency of bond breaking) decreases with increasing amounts of less reactive residual lignin. The fact that, under comparable conditions, large intercepts are always accompanied by low slopes indicates that the highly and less reactive portions of lignin are closely associated. This view is further supported by the finding that the addition of sodium ligninsulphonate substantially lowers the slope, indicating that the existence of the less reactive portion is due to the chemical, rather than morphological structure of the residual lignin.

The fact that the brightness of the pulp usually continues to increase substantially during the period in which the graph is straight indicates that lignin is still present during that period, and thus confirms the ideas outlined above.

The slope for cotton linters (cf. Table I) is of particular interest because it permits us to calculate the efficiency with which bonds are broken in the absence of lignin and hemicellulose. It is found that roughly 12 equivalents of available chlorine are consumed for

every equivalent of bonds broken. For impure pulps this figure is, of course, much higher; thus, it is 210 equivalents of available chlorine per equivalent of bonds broken for unbleached softwood pulp (cf. Table IX). It should be noted that these figures are subject to the uncertainties listed in Appendix 1.

With the evidence at our disposal, we can only speculate on the reason for these high figures. Some of the oxidizing agent is consumed in reaction with residual lignin and in the formation of carbonyl and carboxyl groups. But it is also possible that the real number of bonds broken is larger than the calculated number, since, if two bonds close to each other in the same molecule are broken, a water-soluble oligosaccharide is formed, and the results indicate that only one bond is broken. This is particularly likely to occur in the more accessible regions. Such a mechanism would explain the finding that the slope decreases with increasing amounts of hemicellulose, while the intercept is not affected: the apparent efficiency of bond breaking in hemicellulose is low because of the formation of small, water-soluble fragments.

We have no conclusive evidence on the mechanism of the effect of drying of the pulp on the slope. It is possible that drying renders the hemicellulose less accessible, thus increasing the efficiency of bond breaking (in the example presented, drying lowered the number of equivalents of available chlorine consumed per equivalent of bonds broken from 210 to 110).

None of the reaction conditions studied (temperature, choice of hypochlorite or peroxide, rate of reaction, pH) had any effect on the intercept. This, together with the fact that the intercept is a measure of the residual lignin content for pulps ranging from unbleached to highly purified, suggests that the determination of the intercept may be useful as an analytical tool. We are presently attempting to develop a suitable method. The slope was affected by all of these variables except the temperature. The following conditions gave high slopes: hypochlorite, high reaction rate, low pH.

APPENDIX 1. CALCULATION OF NUMBER OF BONDS BROKEN

Consider the degradation of a sample of cellulose. Let the number of bonds broken per anhydroglucose unit at any time j be n_j, and let the number average degrees of polymerization initially and at time j be P_o^n and P_j^n, respectively. Then

$$n_j = \frac{1}{P_j^n} - \frac{1}{P_o^n}.$$

If we designate the weight—average degree of polymerization by P^w and the heterogeneity value (γ) by

$$U = \frac{P^w}{P^n} - 1,$$

then

$$n_j = (U + 1)\left(\frac{1}{P_j^w} - \frac{1}{P_o^w}\right).$$

The weight—average degrees of polymerization were obtained from the cuprammonium viscosity by a calibration curve based on nitrate viscosities.

The calculation of the number of bonds broken in this manner, though quick and convenient, is subject to the following uncertainties:

1. As it is not practical to determine U for each sample, it is necessary to assume a value for each pulp and to assume that it remains constant during the reaction (*8*). We have found that a value of $U = 1$ is fairly representative.

2. We know that our calibration curve converting cuprammonium viscosity to weight—average molecular weight is only approximately correct, because the cuprammonium viscosity depends not only on the degree of polymerization, but also on the existence of easily oxidized structures in the cellulose chain.

APPENDIX 2. EXPERIMENTAL

Standard Method for Determination of Intercept and Slope. The pulp, which had never been dried, was subjected to a series of sodium hypochlorite bleaches with varying bleach additions. The sample size was 25 g., the consistency 6%, and the temperature 60°. The pH was held at roughly 10 by the use of a buffer containing 2.8 g. $NaHCO_3$ and 5.7 g. Na_2CO_3 per 25-g. sample. Bleaching was continued until all or nearly all of the bleach added had been consumed, as shown by thiosulphate titration. Cuprammonium viscosities were determined, and the intercept and slope were calculated by the method of least squares from points located on the straight part of the curve.

Chlorine Dioxide Treatment (Section 1c). The chlorine dioxide treatments were performed at 25° and 3% consistency. The pH was held near 4.5 by the addition of 10 g.p.l. sodium acetate.

Chlorination and Alkali Treatment (Section 1d). The chlorinations were performed at 25° and 3% consistency for 50 min. The hot alkali treatments were performed at 70° and 16% consistency for 3 hr. using 1.7% (based on pulp) of sodium hydroxide.

Preparation of Sodium Ligninsulphonate (Section 1e). Spent sulphite liquor was dialyzed exhaustively with tap water, and the resulting ligninsulphonate was converted to the sodium salt by ion exchange.

Peroxide Bleaches (Section 2). The peroxide bleaches were performed at 70° and 10% consistency. The sample size was 50 g. Two parts of 42° Bé. sodium silicate solution and 0.04 parts of Epsom salt were added for each part of sodium peroxide used. The pH was held at roughly 10 by the use of a buffer containing 2.8 g. $NaHCO_3$ and 5.7 g. Na_2CO_3 per 50-g. sample. Otherwise, the procedure was analogous to the standard method using hypochlorite (Appendix 2).

Controlling Rate of Reaction (Section 3). The procedure was similar to that used in the standard method (Appendix 2), except that the sodium hypochlorite solution was added to the stirred reaction mixture at such a rate that the residual available chlorine was maintained at roughly 0.12%, based on pulp.

Varied pH (Section 3). The procedure was similar to that used in the standard method (Appendix 2), except that no buffer was used; the pH was held in the desired range by the addition of sodium hydroxide when required.

Sodium Hydroxide Treatment (Section 4). These treatments were performed at 95° and 16% consistency for 2 hrs.

Preparation of Hemicellulose (Section 4). The hemicellulose was prepared by neutralization and centrifugation of a solution obtained by the extraction of a

semibleached softwood sulphite pulp with an aqueous solution of sodium hydroxide (100 g.p.l.) at 45°.

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Groundwood and Chemigroundwood from European Poplarwood

W. BRECHT

Poplar belongs among the fastest growing hardwoods in Europe. Since most of European countries are short of pulpwood, the applicability of poplarwood for the purposes of the paper industry, therefore, has a great significance. It is known that excellent chemical and semichemical pulp can be obtained from poplarwood, if the working conditions are carefully selected. This paper will deal with investigations on the grinding of poplarwood. It was found that the manufacture of groundwood from poplar without pretreatments yields a soft sheet of low density and high absorbancy, the strength qualities of which, however, are not so favorable. Yet by certain pretreatments of the wood surprisingly strong chemigroundwoods are obtained. This is why poplarwood is supreme among the main hardwoods of Europe for the preparation of groundwood pulps. It may happen that in the future more European countries than before will turn to wide cultivation of specially suitable poplar pulpwood as an additional source of fibrous raw material.

It should be recognized that the Italian paper industry has succeeded in producing practically its total demand of groundwood from poplar—as far as it is needed for newsprint in its own country.

Italy is poor in its sources of pulpwood; tied up in a fast industrial development, it studied ways of improving the situation, for example, sorts of poplar were grown which are resistant to diseases (*1*). In order to achieve a very fast rate of growth young hybrids were cared for in beds and finally after 2 years were put out for planting. After the first 10 years, the yield in such wood in Italy amounts to 3.7 to 6.7 cords per acre per year. As these trees are mostly planted in single rows along roads and fields, these plantings of poplar are characteristic for the North Italian landscape today. The total yield now amounts to about 300,000 cords yearly. Two—thirds of this is used for veneer wood and timber, one—third is taken over by the paper industry. For groundwood, the poplars *canadensis* and *caroliniani* are preferred.

Not long ago, the Italian groundwood made from poplar was produced in the normal way without pretreatment of the wood. We in Germany were surprised that the Italian newsprint manufacturers got along with this groundwood, because we had compared the grinding of poplar and spruce in the experimental grinder of the Institute of Paper Technology in Darmstadt. As with the results obtained in other research institutes, we found that while poplar can be ground with less energy than spruce to make a groundwood pulp which drains easily and makes soft, low density papers of high absorbency, its strength properties are much lower than those of groundwood made from spruce.

The contradiction between these results and the practical success in the production of the Italian paper industry just seems to be a contradiction, for the properties of strength of the Italian poplar groundwood are rather the same as those which we have found with German poplar (*2*). It is a matter of fact that the speed of the Italian newsprint paper machines does not exceed 900 f.p.m., despite additions of chemical pulp amounting from 27 to 30%. This refers to newsprint containing groundwood made only from poplar. Although this country—which is poor in wood—has opened and developed a new important source for pulpwood with great energy, the low strength of the groundwood, nevertheless, means a big handicap.

Some time ago, we dealt with another study. Stimulated by the excellent work of Libby and O'Neil on chemical grinding (*3*), we wanted to make a complete survey of the total range running from normal grinding to the production of brown mechanical pulp by means of

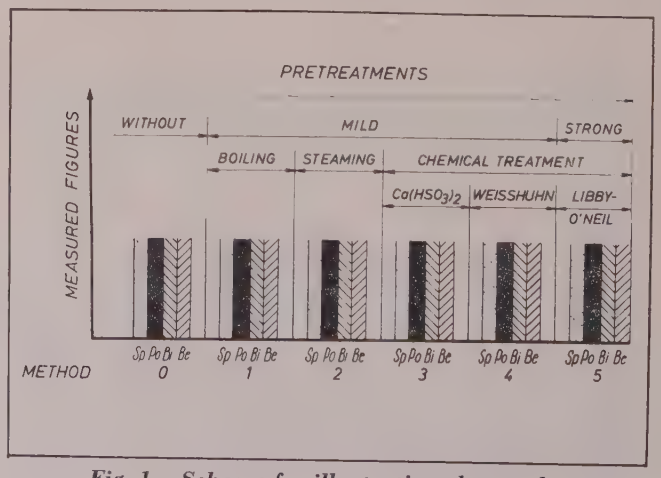

Fig. 1. Scheme for illustrating the results

W. Brecht, Institute of Paper Technology, Technical University Darmstadt, Darmstadt, Germany.

steaming and boiling wood and on further to the various chemical methods of grinding. Here, we wanted to gain a thorough knowledge with regard to the production economy and to the quality for the whole scale of grinding possibilities (*4*, *5*).

In order to obtain a complete picture, the experiments included not only methods of grinding which have been introduced to our technique permanently or temporarily but also some others.

Table I. Methods of Wood Pretreatment

Pretreatment	*Method no.*	*Conditions of the pretreatment*	*Method of*
Without pretreatment	0	Basis of the comparison	
Mild pretreatment			
Boiling	1	1/2 hr. evac., 5 hr. boiling (normal water) at 71 p.s.i. and 120°C., 1/2 hr. cooling with water	
Steaming	2	1/2 evac., 2 1/2 hr. steaming at 57 p.s.i. and 152°C., 1/2 hr. cooling with water	
Chemical pretreatment			
Cooking	3	1/2 hr. evac., 3 hr. cooking with solution of 45 g. SO_2 + 9 g. CaO/l. at 57 p.s.i. and 110°C., 1/2 hr. cooling with water	
Combined method	4	15 hr. drying in air (105°C.), 5 hr. impregnating with solution of 60 g. $NaHSO_3$/l. at 60° C., and atmosph. pressure, 3 hr. steaming at 43 p.s.i. and 143°C., 2 hr. treatment with water (60° C.), 1 hr. cooling with water	Weisshuhn (lignozell)
Strong pretreatment			
Chemical pretreatment			
Cooking	5	1/2 hr. evac., 6 hr. cooking with solution of 143 g. Na_2SO_3 + 32 g. $NaHCO_3$/l. at 200 p.s.i. and 150° C., 1/2 hr. cooling with water	Libby-O'Neil

If I am allowed to discuss here about some of the results, I would like to do so because concerning poplar, we had surprisingly fine results with some ways of wood pretreatment.

EXPERIMENTS

Normal Grinding and Different Methods of Wood Pretreatment

Although I am now mainly referring to poplar—in the frame work of our studies—I want also to give the results, which have been obtained from spruce and from hardwoods like birch and beech, in order to present an over-all picture.

The production of normal groundwood served as a basis for the comparison of the various wood preparations. This is called "method 0" in Fig. 1. The total number of investigations included 10 methods of pretreatment, among these the Fish (*6*), the Bache-Wiig (*7*), the Zimmermann (*8*) methods and a method of chemical grinding already suggested in 1907 by Schwalbe (*9*). But as these particular methods did not turn out anything extraordinary, I shall speak only about five ways in order to simplify the survey. They are shown in Table I.

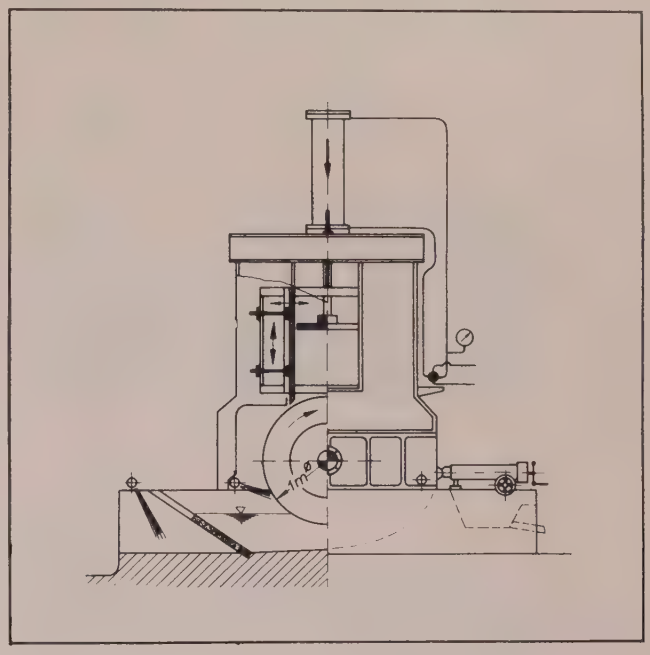

Fig. 2. The experimental grinder

As a mild treatment (method 1), we boiled the wood in water for 5 hr. at 71 p.s.i. and 120°C. Before boiling, the wood was evacuated for 1/2 hr. in a vacuum of 13 p.s.i. In "method 2," the steaming of wood, which also took place after evacuating for 1/2 hr. and the last 2 1/2 hr. was carried out under a pressure of 57 p.s.i. (152°C.). "Method 3" where chemicals were used, may be described as mild. After evacuating for 1/2 hr. the wood was boiled for 3 hr. with calcium-bisulphite-cooking-acid under 57 p.s.i. with 110°C. The method by Weisshuhn (*10*), "method 4" represents a combination, by which wood after drying with hot air is impregnated with a solution of sodium bisulphite at only 60°C. for 5 hr.—then steamed for 3 hr. under 43 p.s.i. (143°C.) and finally washed with water at 60°C. As an example of an extensive method of wood pretreatment, we used under "method 5" the system Libby

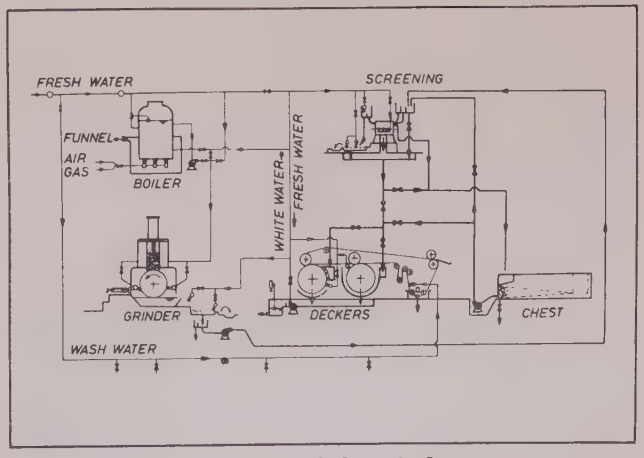

Fig. 3. Layout of the grinder room

and O'Neil (*3*) recommended for the chemical grinding of hardwoods. The wood was first evacuated for $^1/_2$ hr., then boiled for 6 hr. in an alkali monosulphite solution under comparatively high pressure and high temperature.

For the various methods of treatment, Fig. 1 shows a simple scheme which will be used for all stack diagrams for the demonstration of the test results. Under the stacks, which stand for the various kinds of wood as spruce, poplar, birch, and beech, are the numbers of the method which have been taken from Table I, whereas above the stacks the names of the methods are given.

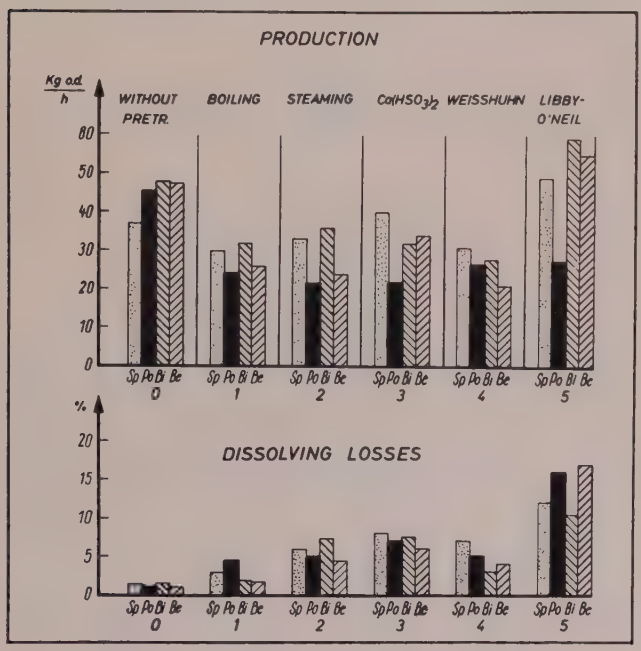

Fig. 4. Production and dissolving losses

Experimental Equipment

The wood pretreatment was carried out in an experimental digester of stainless steel holding about 50 U. S. gal. In order to approach the conditions in practical manufacturing, we used a total length of 30 in. for our logs. After the pretreatment the logs were cut to blocks of about 10 in.

The grinder which has been used (Fig. 2) was a one pocket grinder of a very simple shape. The diameter of the grindstone amounted to 40 in., the grinder width to 10 in. Grinder and electrical drive could take a load up to 100 hp.

Figure 3 shows the layout of the grinder room. One sees the grinder, the screening—consisting of coarse screening and fine screens, the deckers, and the boiler, which allows to work with white water and to warm up the shower water of the grinder in between. But in the test I am referring to, we worked only in the fresh water.

In grinding the same working conditions were always used: a grinding pressure of 14 p.s.i., a circumferential speed of the grindstone of 44 ft. per sec., a temperature in the pit of 55°C., and a consistency of 1.8%. The grindstone was a German-made ceramic stone.

The sharpening of the stone could not be maintained equally for all experiments because this would have resulted in too big differences in the properties of draining of the groundwood. In order to insure a basis of comparison of the methods for an almost equal drainage of the groundwoods, for poplar and for all groundwoods made of hardwood, we aimed at a slowness of 50°S.-R., while the slowness for spruce groundwood was 65°S.-R. This relatively high slowness of 65° would probably have been impossible to obtain for the chemical groundwoods made of hardwood. Therefore, the sharpening of the stone had to be adjusted according to the prevailing conditions. In the strong monosulphite method (method 5), the poplarwood proved to be softened to such an extent, that even a slowness of 50°S.-R. could be achieved only by varying the sharpening treatment and by lowering the grinding pressure from 14 to 10 p.s.i. In the case of the Weisshuhn method (method 4), it was even necessary to take another stone, as the stone used for the other runs did not allow a higher slowness than 35°S.-R. We decided to take a Norton stone A-46-1, which permitted the production of a slower groundwood in this experiment.

Results of Experiments

The economy of the grinding production and the properties of the groundwoods.

The results of the experiments are shown in stack diagrams as explained in Fig. 1. Figure 4 illustrates with the upper diagram the specific production of the grinder—i.e., the weight of groundwood which has been produced per hour under the existing grinding—and working conditions. As we on our continent are accustomed to the metric system it is used here too.

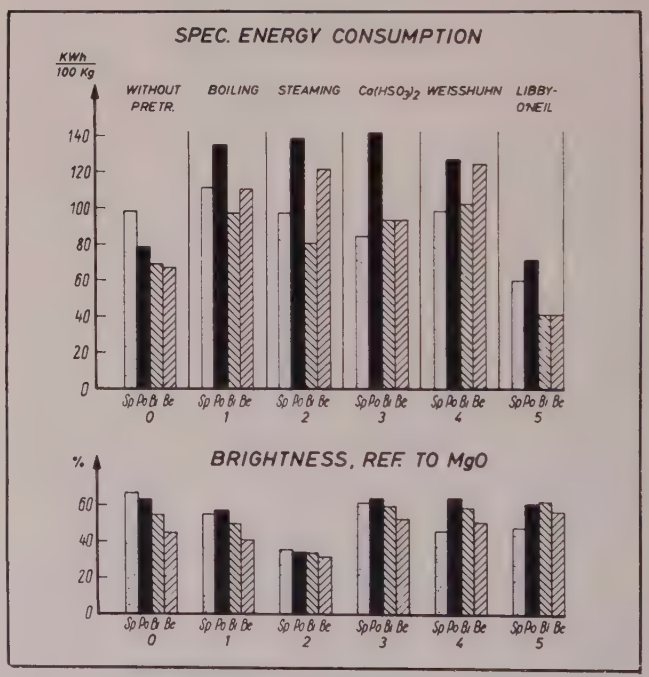

Fig. 5. Specific energy consumption and brightness

It does not make very much difference since the tendencies only count and not the absolute values. We see, that from unpretreated wood (method 0) more poplar groundwood was produced than spruce groundwood. Here, however, it has to be considered, that the slowness of spruce groundwood was 65°S.-R., but

that of the hardwood groundwoods only 50°S.-R. The mild treatment of boiling (method 1) and of steaming (method 2) resulted in an especially sharp lowering of output for poplar, which also occurred when chemicals were used. But the strong monosulphite-method (method 5), which increased the production for spruce, beech, and birch far above the starting value (method 0), shows a decrease for poplar compared with the production of normal groundwood. The loss in production by changing from normal grinding to the other methods has its reason in the fact that the grindstone had to be dull in order to get groundwood of equal slowness.

The illustration at the bottom of Fig. 4 shows the dissolving losses, which determine the yield and, therefore, are of greater economical importance than the specific groundwood production. To get from the dissolving losses to the yield, we also have to consider the losses of solids. But as the latter depend on the screens and deckers in the technical process of grinding, they have not been mentioned here. They usually amount to about 3% of weight. It is clearly to be seen, that for the dissolving losses the method of wood pretreatment plays a much more important part than the kind of wood. The dissolving losses with the production of poplar groundwood without wood pretreatment were 1.5%, almost the same as with spruce, birch, and beech. They increased with the intensity of the treatment and proved to be somewhat higher in steaming (method 2) than in boiling (method 1). Also lower in the Weisshuhn method (method 4), they turned out greater after pretreatment of the wood with calcium bisulphite cooking acid (method 3) and climbed up to the value of 16% of weight in the method with monosulphite (method 5).

Of special influence on costs is the specific energy consumption for grinding expressed in kilo watt-hours per unit weight of oven-dry groundwood. Again we show that poplar, without pretreatment, needs less energy than spruce but a little more than birch and beech. The grinding of pretreated poplar requires more energy with the mild methods (methods 2, 3, and 4). Yet the energy consumption dropped in the monosulphite method (method 5) even for poplar below that for normal grinding. There it ran up to 78 kw.-hr. per 100 kg; in the monosulphite pulp of poplar it amounted to only 71 kw.-hr. Despite loss of specific production in the case of wood pretreated with monosulphite compared with the unpretreated material, there was a saving in energy of almost 10%.

The brightness of the groundwoods measured with the "Elrepho" apparatus as made by Zeiss, using magnesium oxide as a reference, is shown in the lower part of Fig. 5. Normal grinding without pretreatment produces a poplar groundwood which is indeed brighter than that from birch or beech; it is slightly darker than spruce groundwood. With all methods of wood pretreatment, poplar groundwood proved to have the greatest brightness almost without exception. Steaming (method 2) gave the greatest loss of brightness; it was less when boiled in water (method 1). Poplar in contrast to spruce by chemical pretreatment not only showed no loss but even an improvement of brightness in the process using calcium bisulphite (method 3) and in the Weisshuhn method (method 4). These poplar groundwoods almost equalled in their brightness the normal groundwood of spruce. This did not prove to be true for chemical birch and beech groundwood, although there occurred considerable gains in brightness in the Weisshuhn method and in the mild treatment with calcium bisulphite.

We know that the lower strength of groundwood made of hardwoods which have not been pretreated compared with that of spruce is due to the unfavorable distribution of fiber fractions in the normal hardwood groundwoods. Figure 6 shows the effect of various procedures on the fiber fractions (long fibers, short fibers, and fines). The shaded stacks indicate the per cent of groundwood where fiber length has been well preserved, the dotted stacks sum up the relative amount of short fibers and fiber fractions, the empty ones the per cent of fines. The percentage of long fibers in normal spruce groundwood amounts to 18%, the total amount of long and short fibers to 53%, whereas the distribution for normal poplar groundwood although better than for birch and beech groundwood was far less favorable compared with spruce. The pretreatment of poplarwood showed improvement. The content of relatively long fibers increased, although it was still less than the long fiber percentage of normal spruce groundwood. The Libby-O'Neil method proved to give excellent results with long fibers of about 40% and a total amount of fibrous material of 76%. The stock really no longer represents a groundwood pulp. The beech groundwoods were not so good and for birch only the strong pretreatments lead toward clear improvements, where again the Libby-O'Neil method worked extremely well.

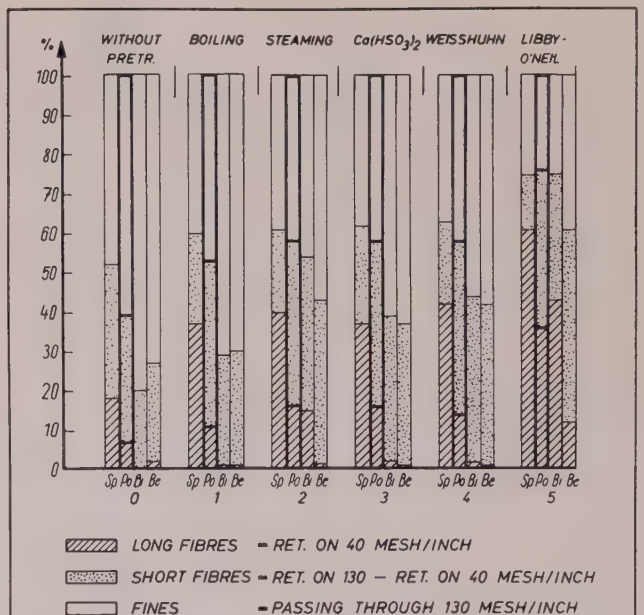

Fig. 6. Fiber fractions

In Fig. 7 on top we see the effect of pretreatment of wood on the tearing resistance, that is for the particular property in which each hardwood groundwood is inferior to spruce groundwood. Again poplarwood yielded far better results than the other two hardwoods. While beechwood in the most favorable case, namely the Libby-O'Neil method gave almost the tearing

resistance of mechanical spruce groundwood, poplar-wood resulted in higher values with both the Weisshuhn method and the Libby-O'Neil method. For birch the results were similar to those of beech.

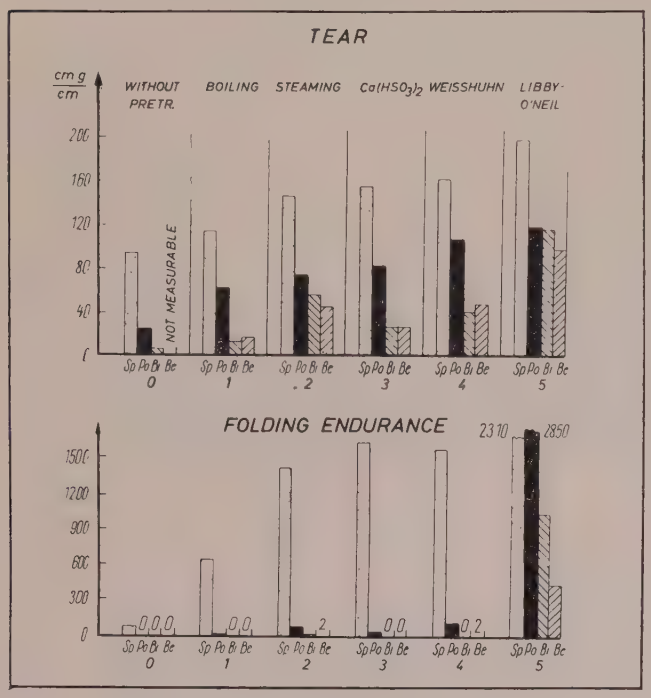

Fig. 7. Tear and folding endurance

The high qualification of the monosulphite method (method 5) for the pretreatment of poplar wood is reflected in the impressive values for folding endurance (Fig. 7, bottom). A folding endurance value of 2850,

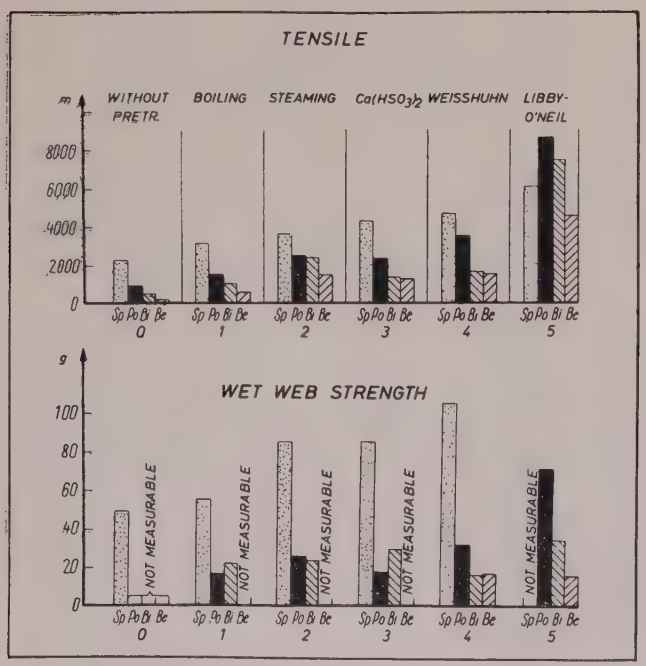

Fig. 8. Tensile and wet web strength

as was found using the monosulphite pretreatment method, is unexpectedly high for poplar groundwood. Also the folding endurance values of birch and beech groundwood produced after the same wood pretreatment exceed by far the one of normal spruce groundwood.

Similar results are obtained for the tensile strength measured by means of the breaking length of dried sheets (Fig. 8, top) and in the form of the wet web strength (Fig. 8, bottom). The monosulphite poplar groundwood value of 8600 m. is something completely new. The value of the wet web strength supports earlier work; here we have to lay stress on the fact that all hardwood groundwoods showed this comparatively high strength property, though they were much freer than normal spruce groundwood.

The Role of the Stock Slowness in the Case of Chemigroundwood from Poplar Wood. As chemical grinding of poplar leads toward astonishingly high strengths, the question arises, how far the better drainage of free groundwoods can be used without too great losses of strength. Figure 9 answers this question for poplar-wood, which was once pretreated by the relatively mild Weisshuhn method (method 4) and another time by the much more extensive Libby-O'Neil method (method 5). The sharpening conditions were handled

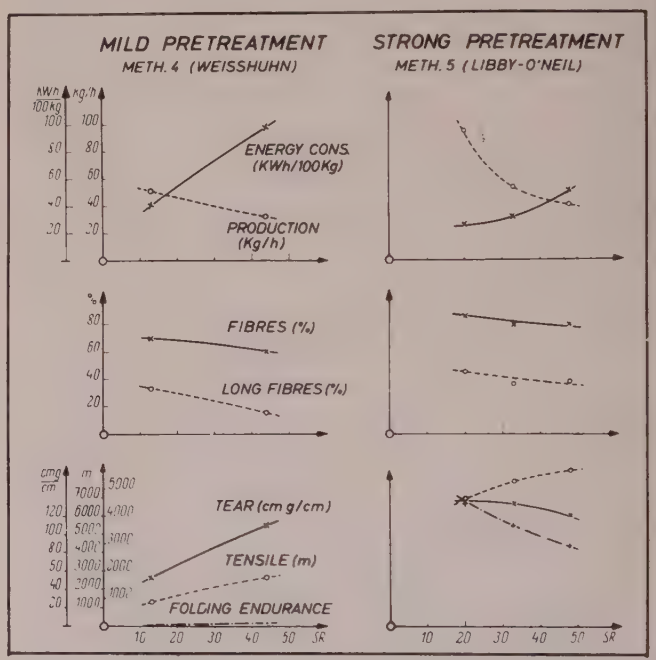

Fig. 9. Influence of slowness °S.-R. poplar chemigroundwood

in such a way that a rather wide range of slowness degrees Schopper-Rieigler for the groundwoods was established.

According to expectations, it turned out that with higher freeness production increased and the specific energy consumption decreased. With the milder methods, which caused only little softening of the wood, the quantity of groundwood produced increased less but the energy consumption showed a greater saving. Yet, the absolute values of the energy consumption were in all cases higher than with the strong method 5—always considered at equal slowness of the groundwoods.

The picture shows furthermore that, when the groundwood became free, we gained more long fibers and total fibers. With the mild method, the values were more moderate, but with the stock becoming

freer, they increased more than in the case of the extensive wood pretreatment according to the Libby-O'Neil method.

This means, for the sheet strength, that here the value of folding endurance as well as the tearing resistance still increased with decreasing slowness, while the breaking length dropped but remained at a high level. The mild treatments showed a different picture. The breaking length was less here and decreased so much that really free groundwoods did not seem to be suitable anymore. Also the tearing resistance and the already rather low folding endurance dropped, probably because the fines showed a loss of mucilage on account of the greater sharpness of the grinder stone.

With the milder methods of the chemical wood pretreatment, a lower slowness of poplar groundwood can be used only to a limited degree because otherwise the strength properties would not be sufficient. Compared with this, the monosulphite method offers the important advantage of being able to utilize a groundwood of even only 20°S.-R.

So it follows that for poplarwood the chemical grinding is of particular significance for it is possible to produce groundwoods even stronger than normal spruce groundwood but also stronger than birch and beech chemigroundwood. This great in crease infolding endurance, in the tear, the tensile, and the wet web strength enables us to get along with relatively low slowness in grinding poplar after a monosulphite treatment. In addition to this advantage of an improved draining property, the production increases remarkably and by this, the energy consumption becomes less. Moreover, certain poplar chemigroundwoods are even brighter than normal poplar groundwood and do not need bleaching if used for newsprint.

Adding of Chemicals to the Grinding Process

The change from normal to chemical grinding requires rather considerably technological efforts. There arises the problem of a sufficiently equal impregnation of the logs with the chemical solution. Therefore, it was attempted to apply a much simpler method which eliminates a wood pretreatment by adding suitable chemicals directly to the grinding process. This means that for the chemical reaction, one chooses the *status nascendi* of the process as such.

About the same time when Cochrane carried out his thorough studies (*11*), we made similar experiments in our grinder room with poplarwood (*12*). We added sodium sulphite, sodium bisulphite, sodium carbonate, and sodium monosulphite from 5, 15, up to 55% of the weight of wood. Naturally, the effects were far from the same as those with chemical wood pretreatment, nevertheless, there were some results. They proved to be best when we used sodium carbonate. Although the groundwood became somewhat slower, the production increased and the specific energy consumption decreased distinctly, breaking length and tearing strength increased considerably. The brightness, however, suffered a small loss. All this was to be observed all the more the more sodium carbonate was added and the higher the grinding temperature was. If stress is laid upon brightness and an increase of strength, sodium monosulphite is preferred. Here also the production increased and the specific energy consumption decreased when much of the chemical was added and when the grinding temperature was high. Breaking length and tearing strength and also the brightness improved. I refrain from giving any figures, because we worked without a complete whitewater system but only with fresh water. Therefore, we had to use much higher percentage of chemicals than would be necessary in practical manufacturing for the same effect, where the largest part of the added chemicals return to the grinding process with the whitewater.

CONCLUSION

The results in this paper show that among the hardwoods in Europe, poplarwood yields specially favorable results when ground chemically. This is true when you aim at slight improvements only, as got by the addition of certain chemicals to the grinder pit, as well as when you want to profit by the far-reaching advantages gained by strong wood pretreatment.

My colleague, G. Jayme, proved by several publications (*13*, *14*) that poplarwood among all main European hardwoods gives especially good results for the production of chemical pulp as well as for semichemical pulp.

This observation may be of no immediate significance for the American continent, at least at the present time. But poplar trees, especially certain specific hybrids, are among the fastest growing hardwoods of Europe. It may therefore happen that the European paper industry will soon lead the way to the development of an increase in supply of fibrous woods for those countries which are currently short of wood through the methodical growth and utilization of poplarwood as is being done in Italy for example.

Apart from the first European preparatory work and suggestions as to the production of semichemical pulp and chemigrinding, American and Canadian scientists (*3*, *15*, *16*) have done and are doing outstanding pioneer work. We Europeans appreciate and acknowledge this fact with much gratitude.

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Physical and Anatomical Characteristics of Hardwoods

J. D. HALE

Describing the anatomical types of hardwoods, the paper attempts to explain the anatomical basis of the technological properties of wood. Equating variations in cell structure of hardwoods with variation in specific gravity of wood, the paper indicates the anatomical basis of shrinkage and swelling of wood in the submicroscopic structure of the walls of the wood fibers that determine the direction of the grain and by this fact determine also that wood normally shrinks or swells across the direction of the fibers. Relation of anatomical characteristics of wood to ease of pulping as well as to yield and fiber characteristics of papers are implied. Referring to the interest of the paper industry in taking appropriate measures to grow trees of superior quality to produce pulp in the future, a simple method for inventory or appraisal of woodlands is suggested that should facilitate and coordinate the work of silviculturists and tree breeders in producing superior trees.

THE terms "hardwood" and "softwood," widely used without reference to physical hardness or softness of wood, are terms of convenience for designating two distinct botanical groups of trees or their wood. In practice, softwoods are trees commonly known as conifers, most have needlelike or scalelike evergreen leaves. Classed as seed-plants known as Gymnosperms, the conifers are the only trees of this botanical subdivision that produce wood of commercial significance. The hardwoods—dicotyledons—are the most important of the very large botanical subdivision of seed-plants known as Angiosperms. While less than 50 genera of softwoods comprise about 500 species, some 3000 genera of dicotyledonous Angiosperms include many thousands of species that grow to tree size (*20*).

PROPERTIES OF WOOD DETERMINED BY CELL STRUCTURE

Wood, like all other parts of plants, is composed of cells. While plant cells are of many kinds, all have the common feature of a more or less substantial cell wall that surrounds a cavity. The cells of wood are principally of hollow tubular shape, tapering to points at each end. Wood consists principally of such cells packed tightly together (with ends overlapping) and parallel to the axis of root, trunk, or branch.

Anatomical features of these cellular components are typical for different species. Specific differences in cell structure may cause one kind of wood to differ widely from another in physical or mechanical properties. Since paper consists of artificial mixtures of plant cells—arranged in the form of sheets—it is evident that important aspects of paper technology must be based on critical appreciation of plant anatomy. Wood anatomy has particular significance in connection with paper made from wood pulp since the cell structure of pulpwood species affects not merely the physical or mechanical characteristics of the paper made from it, but primarily the ease with which the wood may be reduced to pulp. Moreover, if geneticists are to succeed in producing trees with wood of superior technological properties, the criteria of wood quality will necessarily be anatomical.

The substance of the walls of wood cells is tough and durable, remarkably uniform in basic chemical composition and with specific gravity reported as about 1.53 (*21*). A cubic foot of the cell-wall substance would weigh some 95 lb. However, wood of the various kinds in most common use is much lighter than this because of the void spaces in wood presented by the cavities of the component cells. It is the common practice to compare woods according to their weight per cubic foot at a moisture content of 12% of the weight of wood when oven-dry. On this basis, the limit of variation in density likely to be encountered in woods of commercial importance ranges from a low of some 5 lb. in the case of the exotic balsa, up to the opposite extreme of over 80 lb per cu. ft. for some of the heaviest hardwoods.

The weight per cubic foot of woods most commonly used in North America is within the range between about 20 and 55 lb.—the extremely light or extremely heavy kinds having their special uses. The differences in weight are, of course, related to difference in the average thickness of cell walls and in the average diameter of the cells, anatomical characteristics which affect the mechanical properties as well as the density of wood. Obviously when cells are thick walled or of relatively small diameter, the wood tends to be heavy, hard, and strong. When cell diameters are large or the walls relatively thin, the resultant wood tends to be light in weight, soft, and relatively weak.

THE FORMATION AND GENERAL APPEARANCE OF WOOD

The young shoot which a hardwood or softwood tree seed sends up forms a layer of wood around a soft central core of pith. Trees with an ancestry developed in the temperate latitudes, where periods of growth alternate with the winter resting periods, form each year a more or less definite layer of wood outside the wood previously formed. This layered structure is distinguishable on the ends of logs of most of the common kinds of trees where the layers are visible in section as concentric rings. The fact that each of these distinct layers consists typically of the wood added during one year has given them the name "annual layers" or "annual rings."

Successive layers are deposited on the surface of previously formed wood through the agency of a layer of living tissue, called the cambium, situated between the wood and the bark. The cambium envelops the

J. D. HALE, Ottawa Laboratory, Forest Products Laboratories of Canada, Ottawa, Ont.

wood of trunk and branches in a close-fitting film. Each year a layer of wood is deposited outside the previous wood of trunk and branch by this tissue, which at the same time generates the bark from its outer surface.

When first formed, wood is typically light colored in healthy trees so that the outermost layers have characteristically pale yellowish or off-white shades. In many species the wood darkens after it has become separated from the cambium by a number of subsequent layers, undergoing slight chemical and physical changes. In such trees only the outside layers of wood are light colored and this outer layer is sharply distinguished from a naturally darker region called the "heartwood" at the central portion of the log. The light-colored outer wood is known as "sapwood," and may be composed of many years' growth, its thickness depending in general on the age of the tree, the species, and the rate of growth. In some species, however, the heartwood has the same light color as the sapwood.

Sapwood functions as the conductor of sap, chiefly water derived through the roots from the soil. Sap is conducted upward to the leaves where, from the gases of the air and the energy of the sun's rays, food is manufactured and conveyed downward through the inner bark to the live tissue enveloping the wood, where the food is further elaborated into new layers of wood and bark. Young trees may, of course, consist entirely of sapwood.

The cell structure of both hardwoods and softwoods is similar in that it is so evidently adapted for conduction of liquids along the tubular cells parallel to the axes of roots and stems. These tubular cells characterized by pointed endings have been designated under the general term "prosenchyma." The preponderant direction of the main axes of the prosenchyma cells is called the "grain," which is another convenient technical term which means merely the direction of the cells that determines the direction of cleavage.

Before describing typical anatomical characteristics of hardwoods it is desirable to refer to the general cell characteristic of softwoods, a subject quite familiar to most papermakers insofar as it affects their product. One of the principal characteristics of softwoods is the uniformity of the prosenchyma cells. These cells—the papermakers' so-called "fibers"—may vary in over-all dimensions and in thickness of their walls but are the type known as "tracheids" which is a word used to signify a conductive cell which has a wall with bordered pits in it, especially near the ends of the cell, which facilitate transmission of liquids. The pit is a small opening in the cell wall and its border is a depressed circular area of the cell wall immediately surrounding the pit opening. The position of bordered pits coincides in neighboring tracheids so that each such opening is paired with a similar one in the neighboring tracheid with the depressed borders forming a small lenticular cavity shape (the pit chamber) immediately surrounding the openings. The intercellular substance forms a thin pit membrane across the pit chamber so that sap which traverses the pits must pass through the pit membrane which is permeable to aqueous liquids and even to finely divided solids in suspension. The pit membrane which separates the neighboring cells has a thickened impermeable area (called the torus) in the center opposite the pit openings, but as the membrane occupies a median position in the pit chamber of active sap-conducting tissue, the torus does not interfere with the passage of sap. In heartwood, however, the pit membrane generally appears to change its position so that the torus is pressed against one of the pit openings, with sufficient force to prevent or greatly limit the flow of liquid (*1, 4, 20*).

In addition to the vertically aligned tracheids of softwoods, groups of cells also extend horizontally and radially across the grain—from the central pith to the bark. Cells that form the rays are short and so small as to pass readily through the fourdrinier wire. Some tiny tracheids occur in the rays of certain softwoods, but most of the ray cells are the so-called parenchyma cells which have more or less square endings and simple pit openings without borders. As special organized structures, rays affect the physical properties of wood but the small size of their component cells causes them to be lost in chemical pulping processes. The types of cells found in softwoods have their counterparts in the hardwoods, the wood of which is also characterized by other more specialized cell types.

ANATOMY OF HARDWOODS

The microscope reveals that hardwoods differ from softwoods in that the wood contains vessels which, on examination of the clean-cut end of a hardwood log or board, appear as great numbers of more or less rounded holes or pores in the wood surface. These pores are transverse sections of the vessels, cells of much larger diameter than the fibrous elements. The fibrous cells in hardwoods, which compose the greater portion of the wood, are shorter than the tracheids of softwoods, and are often so small in diameter that the cell cavities are indistinguishable when examined with a pocket magnifier. The vessel segments are comparatively short tubular cells with open endings which fit together like minute lengths of pipe and form long continuous channels especially adapted for conducting sap. Owing to the porous appearance of wood exhibiting vessels when cut at right angles to the grain, the hardwoods are sometimes known as the porous woods.

For purposes of identification, hardwoods are divided into two general classes on the basis of pore arrangement. One class contains pores which are not only very much larger in the early wood than in the late wood (see Fig. 1 white oak transverse section illustrating ring-porous structure), but are also close together in a more or less continuous layer in the early-wood region of the annual ring. Woods with such a distribution of pores are known as ring-porous woods. Ash, elm, and oak are typical species. Other species with pores of more nearly uniform size distributed fairly uniformly throughout the annual layers are known as diffuse-porous woods (see Figs. 4 and 5 yellow birch transverse sections $\times 12^1/_2$ illustrating diffuse-porous structure). Birch, maple, and poplar are typical diffuse-porous woods. In diffuse-porous woods, annual layers are sometimes difficult to distinguish, as some of these woods do not show the distinct contrast in texture between early wood and late wood that is found in some of the softwoods. Certain tropical

Fig. 1. Ring-porous wood. White oak (Quercus alba) *transverse* ×5. *Wood of high density showing a rate of growth of some 12 to 13 rings per inch*

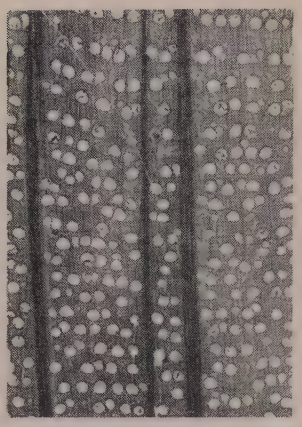

Fig. 2. Ring-porous wood with very narrow rings. White oak (Quercus alba) *transverse* ×5. *Wood of low density showing a rate of growth of some 45 rings per inch*

woods, both hardwood and softwood, grow without very definitely distinguishable seasonal layers.

In the sapwood of both classes of hardwoods, the vessels are typically open, but, as the growing tree ages, the cavities of the heartwood vessels of many species become filled with ingrowths of small cells. These growths are known as tyloses. In some woods, the cavities become filled with deposits of gummy substances. The effect of tyloses may be illustrated by reference to the fact that one can blow through long sticks of oak sapwood or even through heartwood of the red oaks, where the vessels are mostly unobstructed, while heartwood of the white oaks, its vessels filled with tyloses, is relatively impermeable. Tyloses are visible, in the large vessels of the white oaks and certain other hardwoods, as shining structures like microscopic soap bubbles.

Wood rays are typically more conspicuous in hardwoods than in softwoods. In some species, as for example the aspens (*Populus* spp.) rays are thin radial ribbonlike structures only one cell wide, as in softwoods, but most of the hardwoods are characterized by rays from one to several cells in width. Whereas the uniseriate rays typical of aspen are inconspicuous, being sometimes less than 10 μ wide tangentially and some 200 or 300 μ in height, measured along the grain, the multiseriate rays of other hardwoods are naturally a much more prominent anatomical feature. Multiseriate rays range from three to many cells in width at their widest point, tapering to uniseriate margins. The widest rays in common North American hardwoods occur in species of oak where 35 or more cells may be counted across the width of a single broad ray amounting to a total measured width of half a millimeter or more. In the white oaks the larger rays attain a height of more than 2 in.

Rays are composed of cells called parenchyma, which are much shorter than prosenchyma cells and have typically square ends.

Hardwoods also may contain parenchyma cells interspersed with and parallel to the prosenchyma. A layer of such cells usually occurs at the boundary of each annual layer and, in some species, wood parenchyma cells are grouped about the vessels or may occur in bands that follow the curvature of the growth rings. Parenchyma cells are not primarily conductive, their function being that of storage of cell contents, in contrast to the conducting prosenchyma cells which lack protoplasmic content. In the active growing period of the tree the parenchyma cells may be filled with starch grains. Both wood and ray parenchyma cells have square or abrupt endings and simple pits without borders. Although comparable in diameter to the wood fibers, parenchyma cells are so much shorter that they are typically lost in chemical pulping processes.

The anatomical structure of hardwoods is, therefore, a succession of concentric layers consisting principally of vertical prosenchyma, but with frequent radially aligned groups of ray parenchyma cells. According to the measurements reported by Myer (*18*), in most hardwoods, excluding oaks, the rays occupy from 5 to 20% of the total volume of wood, with average ray volume in the neighborhood of 14% of the total wood. Myer's measurements indicate that in oaks the rays occupy from 20 to 30% of the total volume of wood.

The average weight per cubic foot of wood, air-dry cited for some 35 kinds of North American hardwoods tested at the U. S. Forest Products Laboratory, exhibits a range from some 26 lb. per cu. ft for aspen and basswood to a high of some 51 lb. for the true hickories (*24*). The median of these values is at some 37 lb. A similar range is given by the Forest Products Laboratories of Canada for 32 species of Canadian hardwoods (*6*) with indicated median value within a pound of that computed for the Madison data. This wide range in density is accounted for by anatomical differences characteristic of different species. The figures for density of wood are mentioned since these figures are immediately indicative of possible yields of pulp obtainable from North American hardwoods. It will be desirable also to give some indication of the variations in density of wood that may be associated with anatomical variation.

VARIATIONS IN HARDWOODS

As in the case of softwood species, the hardwoods are subject to natural variation so that different shipments of wood of the same species may differ somewhat in average density and pulping properties. As well as being indicative of the weight of pulp obtainable from wood, the density gives valuable indication of physical or mechanical properties of wood which are regarded as functions of density and specific anatomical structure (*19*, *22*). In hardwoods, variation in density seems greatest in the ring-porous species, where there is great contrast in texture between the band of large cavities representing the spring pores and the band of heavy fibers in the last formed wood, summerwood.

Trees of ring-porous species commence the growing season by forming a layer of large pores. If the growth of the annual layer stops without the addition of much fibrous wood, it is obvious that such slow growth, which produces a narrow ring with very little dense fibrous material, results in the production of wood containing an unusually large proportion of air spaces, (see Fig. 2 white oak transverse section ×5 with very narrow rings, about 45 rings per in.). Ring-porous hardwoods of excessively slow growth are for this reason lighter in weight and mechanically weaker than the average for

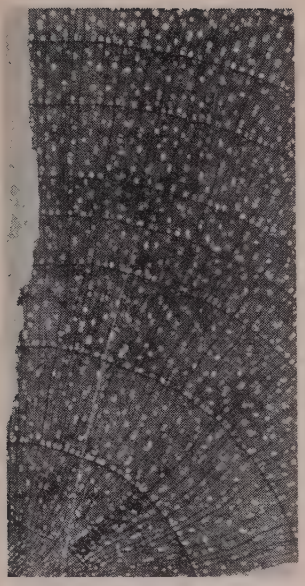

Fig. 3. Diffuse-porous wood—first 10 annual rings show juvenile stage. Yellow birch (Betula lutea) *transverse* $\times 12^1/_2$

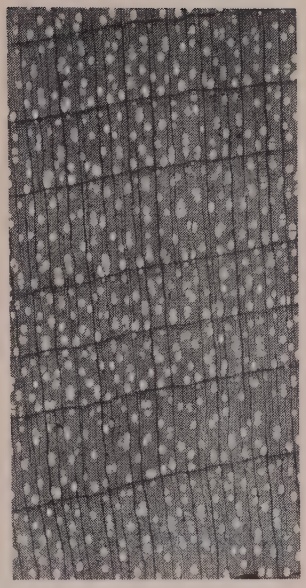

Fig. 4. Diffuse-porous wood 70th to 76th annual rings. Yellow birch (Betula lutea) *transverse* $\times 12^1/_2$ *mature wood of same log as no. 3*

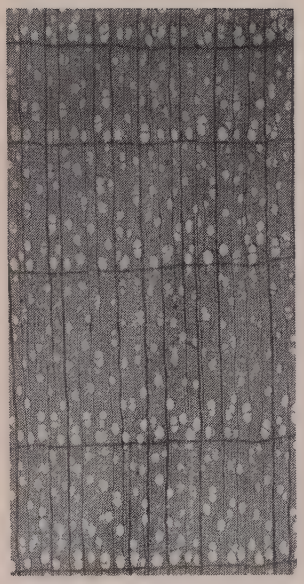

Fig. 5. Yellow birch (Betula lutea) *transverse* $\times 12^1/_2$. *Illustrates uniform diffuse-porous structure*

the species. Experienced inspectors may, therefore, be aided in selecting dense, strong material of certain ring-porous species by noting that within certain limits some ring-porous species decrease in density with decreasing width of annual layers.

When, on the other hand, ring-porous woods form extremely wide rings, the density is likely to be below the maximum and often far below average. It appears that when the cambium produces cells extremely rapidly it tends typically to make them relatively thin walled with a high proportion of cell cavities and a resultant type of lightweight wood. This is recognized in selecting certain ring-porous woods for high density and consequent high strength, as is shown in specifications for handles of ash and hickory for striking tools which call for ash with not less than five rings per in. nor more than 15 for the highest grade of handle, while for hickory handles, a limit of not more than 17 rings per in, is set to guide selection of the heaviest wood for handles of the highest grade (*23*).

In view of the variety of influences that may have a part in the formation of wood, it is not surprising that wood of the same species from different regions may have somewhat different properties. Soil conditions, moisture, temperature, and density of the surrounding stand, are a few of the important environmental factors. Also, the influence of maturity in age or in size on the density of wood appears to cause large or old trees to produce wood of lower density for a given width of rings than the trees produced during their initial stages when relatively young and small (*12*).

Diffuse-porous hardwoods lack the row of extremely large pores that characterize the early wood of the annual layer of ring-porous wood, and in this sense are the more uniform in structure. The heavier native woods of this type, such as birch and maple, seem much less subject to significant variations in structure and density than the ring-porous woods. The lighter of the diffuse-porous hardwoods, however, show some variations in density that appear to be related to variations in rate of growth. Wood of a medium growth-rate in these species tends to be somewhat denser than that of extremely fast or extremely slow growth. Instances of the practical importance of such variations are continually noted. For example, in American yellow poplar (*Liriodendron tulipifera*), where wood of relatively low density is the rule in large forest grown trees, wood material of excessively high density came to the attention of the Ottawa Laboratory, F.P.L. of C. in 1942, in shipments of veneer for aircraft plywood where lightness was required. The wood in question originated from relatively young trees with wide annual rings and appeared to be an example of the capacity of young trees growing reasonably fast to produce wood of exceptionally high density.

Abnormal wood is sometimes found in trees of normal age-class and rate of growth. An instance was noted in the case of one abnormal basswood tree received in a shipment of five trees selected as representative of the species. Abnormally low density of wood of the tree in question was found to be due to a larger proportion of pores than is normal. The exceptional wood appeared to represent an inheritable character that was not due to purely environmental growing conditions.

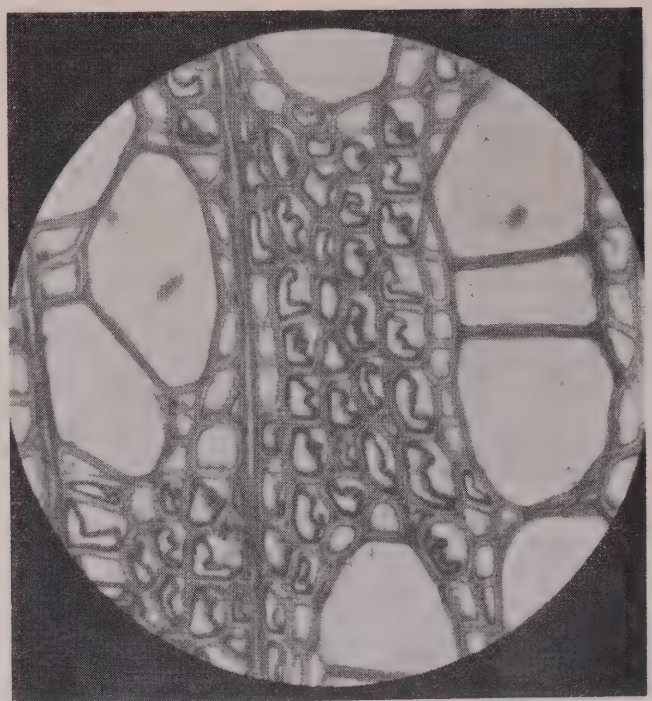

Fig. 6. Aspen (Populus tremuloides) *transverse* $\times 425$. *Illustrates gelatinous fibers of tension wood. The dark inner "gelatinous" lining in "gelatinous" fibers characteristic of tension wood has collapsed in sectioning*

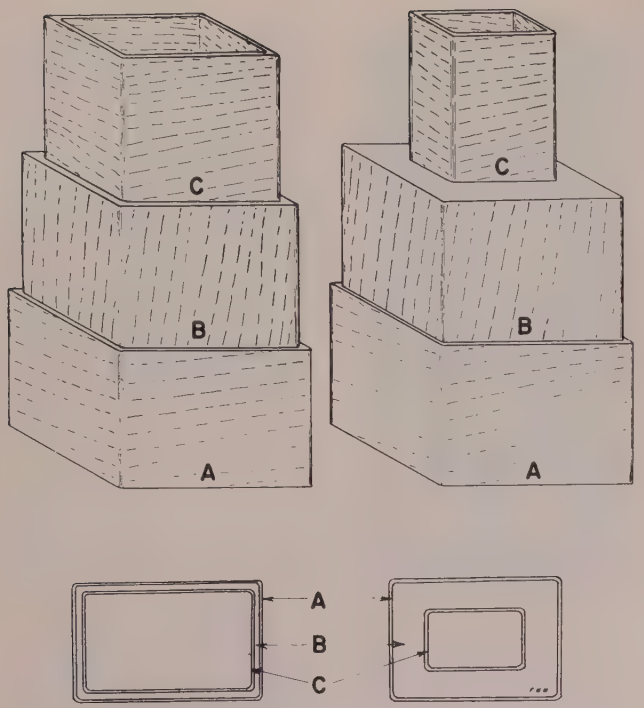

Fig. 7. Diagram highly magnified illustrates structure of thin-walled fiber (left) and thick-walled fiber (right) dissected to indicate the three differentiated layers of the secondary wall. Transverse view (lower) and side view (upper)

Dotted lines indicate direction of alignment of submicroscopic components which in outer and inner layers A and C is nearly perpendicular to that of the thick mid-layer B. Mid-layer B can dominate shrinkage in thick-walled cells because of its relatively great thickness causing cells to shrink in diameter rather than length. In abnormally thin-walled cells where all three layers have more nearly comparable thickness, mid-layer B does not completely dominate and such cells may, therefore, shrink in length as well as in diameter.

An abnormality found in hardwoods that is being widely studied is the so-called "tension wood" which is a peculiar type of wood on the upper side of branches. It also occurs in leaning trunks. More difficult to detect in hardwoods than the compression wood of conifers which is related to the lower side of leaning trunks, its occurrence is variable and is typically on one side of the trunk where it is likely to be associated with eccentric widening of the growth rings in regions of its greatest development. In converting logs, any tension wood areas tend to saw woolly so that tension wood areas are made visible by the "woolly" surfaces on the faces of boards.

Tension wood can be distinguished by a luster that gives such wood a somewhat lighter color than the surrounding normal wood. In aspen poplar studied at the Ottawa Laboratory, test portions of the trunk where tension wood occurs at maximum development was found to be significantly higher in basic specific gravity than normal wood (0.450 as compared to 0.414 on the basis of weight oven-dry and volume green). In other species, however, the relationship between tension wood and high specific gravity was not evident (*7, 9*).

The presence of gelatinous fibers is the criterion of tension wood. Under microscopic examination, gelatinous fibers are detected readily in transverse sections by the presence of a so-called gelatinous sheath like an inner tube within the fibers (see Fig. 6, aspen transverse ×425 showing "gelatinous fibers" characteristic of tension wood). Except in toughness, tension wood was found to be lower in mechanical properties for its weight than normal wood when tested in green condition (*9*). Tension wood has the peculiarity of shrinking somewhat more than normal wood along the grain.

Of possible interest in connection with pulping tension wood, it is reported as slightly lower in lignin content than normal wood and higher than normal in cellulose and pentosan. A. A. Marra and W. M. Schall (*4*) report that the gelatinous layer of the fibers is largely alpha-cellulose with other unidentified substances. Tension wood studied at the Ottawa Laboratory, F.P.L. of C. showed significantly higher alpha-cellulose content and in pulping tests it proved less responsive than normal wood to beating. (Ref. to Clermont and Bender, *Pulp & Paper Magazine of Canada, July, 1958*, Chemical Composition and Pulping Characteristics of Normal and Tension Wood of Aspen and White Elm.)

ANATOMICAL BASIS OF SHRINKAGE AND SWELLING

Shrinkage of wood, unless otherwise indicated, refers to loss of volume in drying from saturated to oven-dry condition expressed in per cent of volume at saturation. One of the most significant characteristics of wood and one that dominates all industrial processing and utilization of seasoned wood is its habit of shrinking when dried to moisture contents below its fiber-saturation point and its hygroscopic dimensional changes in response to changes of moisture content

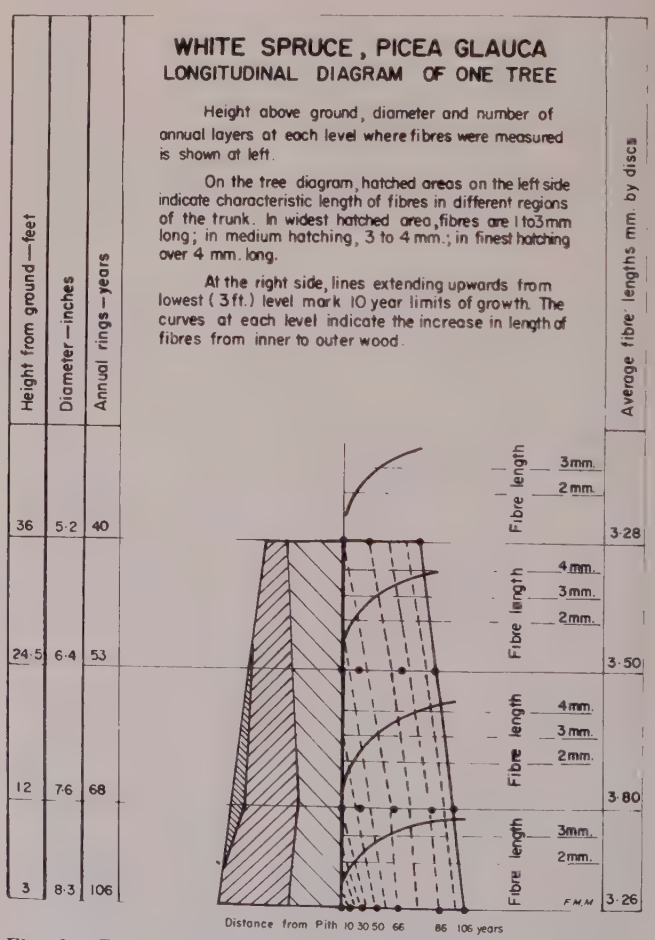
WHITE SPRUCE, PICEA GLAUCA
LONGITUDINAL DIAGRAM OF ONE TREE
Height above ground, diameter and number of annual layers at each level where fibres were measured is shown at left.
On the tree diagram, hatched areas on the left side indicate characteristic length of fibres in different regions of the trunk. In widest hatched area, fibres are 1 to 3 mm long; in medium hatching, 3 to 4 mm.; in finest hatching over 4 mm. long.
At the right side, lines extending upwards from lowest (3 ft.) level mark 10 year limits of growth. The curves at each level indicate the increase in length of fibres from inner to outer wood.
Height from ground—feet
Diameter—inches
Annual rings—years
Average fibre lengths mm. by discs
36
5·2
40
3·28
24·5
6·4
53
3·50
12
7·6
68
3·80
3
8·3
106
3·26
Fibre length
3mm.
2mm.
4mm.
3mm.
2mm.
4mm.
3mm.
2mm.
3mm.
2mm.
F.M.M.
Distance from Pith 10 30 50 66 86 106 years

Fig. 8. Diagram illustrating variation in fiber length in different parts of the trunk of softwood tree. Fiber length is shortest in juvenile wood, longest in mature outer wood in similar trends of variation at all levels

below that point. (The moisture content of wood at f.s.p. is about 30% of the weight oven-dry.) The mechanism that causes such dimensional changes has of course attracted investigation to explain why this shrinkage and swelling of wood takes place across the grain and only to a slight extent—a small fraction of 1% of the original dimension—along the grain. Since such behavior seemed obviously related to the general parallel alignment of the prosenchyma, the discovery that the submicroscopic alignment of component fibrils of the secondary walls of prosenchyma cells is preponderantly parallel to the cell axes appeared to explain how cells could shrink in diameter without shrinking in length (*11*, *16*). It was reasoned that the loss of moisture held between parallel fibrils of the cell wall permitted or forced these vertical fibrils to draw closer together, filling the space formerly occupied by moisture, and so causing the cells to shrink in diameter. Reversal of the process, by exposing dry wood to moisture, could explain the swelling reaction.

This did not explain fully why shrinkage of wood is a function of the specific gravity so that, within limits, heavy woods are normally capable of greater shrinkage than lightweight woods, nor did it explain why wood of abnormally low specific gravity for its species should exhibit (as it does) abnormally high shrinkage along the grain. The situation is more fully explained by reference to the fact that the secondary wall of prosenchyma cells has generally three recognizable layers (*2*, *3*), all of which may be capable of contributing to the direction of dimensional change (Fig. 7). Since the middle layer, normally characterized by longitudinal fibrillar structure is by far the thickest, it dominates dimensional changes of the cell, thereby causing such dimensional changes to take place across the cell axis. The inner and outer layers of the cell wall are always thin and have fibrillar structure aligned nearly perpendicular to the longitudinal fibrils of the thick mid-layer, so that these two thin, skinlike layers presumably exert some stress along the grain perpendicular to the transverse dimensional change. It may be supposed that these thin layers of the outer and inner surface are normally too feeble to cause actual dimensional change along the grain, but may be able to exert some small shortening effect in cells with walls so abnormally thin that the central layer is sufficiently scanty to be dominated by its two neighboring layers. Wood characterized by such thin-walled prosenchyma would be abnormally light for its species, and the fact that such lightweight wood does exhibit abnormally great shrinkage along the grain (*15*) supports the theory of shrinkage just outlined. Such circumstances can also help to explain why shrinkage of wood is normally a simple function of specific gravity, for in wood species of light weight the component fibers will have walls thin enough to be in some way affected by their covering layers. As it is supposed that the outer and inner skinlike layers of such walls are generally of constant thickness, such layers might be capable of exerting a constant force in restraint of transverse movements of the layer they enclose. Such restraint would be most effective in woods of low specific gravity characterized by thin cell walls and least so in dense woods which have thick-walled cells. This basis of normal cell wall shrinkage in connection with the annual ring structure of wood and restraint of transverse shrinkage by the rays has contributed toward explaining why the radial shrinkage of wood is typically less than the tangential shrinkage (*10*).

While shrinkage is in general a function of specific gravity, it is obviously of advantage to find exceptional woods that shrink less than would be expected for their weight. If, therefore, the average shrinkage registered by different wood specimens in drying from the fully expanded saturated condition to zero moisture content is plotted as a regression against their respective basic specific gravity, a simple straight line relationship can be drawn through the plotted points to indicate average shrinkage behavior of the specimens. The equation of such a line is expressible in the form of a simple constant multiplied by the basic specific gravity. Such a graphic picture of the average shrinkage behavior can be of value in facilitating recognition of specimens characterized by the least shrinkage for their density in that these exceptional specimens are made conspicuous by their plotted position significantly below the line of average shrinkage. More simply, if the shrinkage (expressed in per cent of original volume) is divided by its basic specific gravity, a figure is obtained that can be called specific shrinkage, since it indicates how much wood shrinks in relation to the specific gravity. The average specific volumetric shrinkage for North American woods has been determined as fairly close to 27 for hardwoods (*14*, *19*). Exceptional woods with specific shrinkage far below this figure may, of course, have particular usefulness on this account. It is of some interest, however, that even specific shrinkage is subject to significant variation in wood of large old trees.

Specific shrinkage appears to be greatest in the central wood of such trees and least in the outer wood (*8*). Such distribution may indicate that the specific shrinkage increases as wood ages in the standing tree, and that a century or so in the central portion of the bole may have slightly affected the physical capacity of wood for bound water, thereby increasing its fiber-saturation point. This type of variation has only recently been observed and needs further investigation.

ANATOMICAL APPRAISAL OF VARIABLE SPECIES BY MEANS OF THE ASSUMED NORM

It is desirable to be able to predict what properties of wood a stand of trees may be expected to produce under known conditions of tree growth. With respect to current knowledge in technological properties of wood, methods for insuring more accurate prediction than is now generally practised are available and should now be considered. For example, if the woodlands manager needs to know what to expect in specific gravity or wood from his particular woodlands area, it is a reasonably simple matter to obtain the information by appropriate sampling of the area in question. However, the sampling and the recording of data should be such that the information on specific gravity or any other criterion of quality applicable to particular conditions of growth can be made to apply to comparable conditions of growth elsewhere. Such application should of course be part of any method of sampling that is truly representative.

In appraising wood representative of a woodlands area, some preliminary information as to composition

of the stands is desirable so that test trees of each species may be selected as representative of the principal significant diameter-classes within each age-class. The test data are computed for each tree so that such information may be appropriately weighted according to the volume of wood represented by trees of different sizes. Such information, recorded for each different site of ecological significance, provides the basis for the information required.

The form of recording is particularly important. Supposing that the appraisal concerns a pulpwood area and that the significant criterion of wood quality under investigation is the basic specific gravity, each species sampled will be represented by a plotted regression line indicating the basic specific gravity of significant diameter-classes within each age-class. For example, age-class 41 to 60 years would be graphically represented by a regression curve showing specific gravity of the trees of significant diameter classes—say from 6 in. plotted left to right at appropriate diameter intervals up to the maximum. The effect of different sites or ecological areas may be indicated by a regression graph for each of such subdivisions. Significantly different sites will probably have significantly different levels of specific gravity with individual regression graphs that are more or less parallel. Any effects of annual ring width on specific gravity will thus be distinguishable by the slope of the recorded curves. Ring-porous hardwoods that tend to decrease in specific gravity with decreasing width of rings will have graphs slanting up from low specific gravity of the smallest diameter at the left to the larger diameter-classes at the right. On the other hand, the graph of specific gravity for spruce, which increases with decreasing width of rings, will descend from its highest point at the small diameter to lower levels for the wood of larger diameter classes. As recent investigations with coniferous species of identical origin but grown in both moist and dry areas indicate, the specific gravity of wood grown in moist areas may be expected to exceed that of wood from excessively dry ones.

The regression graphs for a uniform age-class indicating specific gravity of wood by trees of ascending diameters may therefore show as many different parallel curves (or straight lines) as the number of ecological subdivisions tested. The method of plotting the data is all-important in that it supplies a criterion that can be regarded as a species norm by which to judge trees growing under the same conditions. Trees that vary significantly from this norm—that is to say trees sampled under apparently similar growing conditions with specific gravity far above or below the specific gravity of the regression graph—are thereby made conspicuous and singled out for attention. That it constitutes a reliable norm will be made reasonably apparent by continuity of the regression graph which is assured by the comparative homogeneity of the half dozen trees that establish each plotted point.

The value of the information to the woodlands manager is that by appropriate sampling it appraises the specific gravity of wood in the available stand so that by reference to stand tables and yield tables the forester can apply the data to the composition of the forested areas, finding out thereby how many pounds of wood are available.

The fact that propagation of trees with superior types of wood has become recognized for its potential importance to industry raises the desirability of developing methods for recognizing superior trees. The method just described for establishing a species norm can be used for a wide variety of growth characteristics associated with tree form or with technological properties of wood. It is well adapted for detecting trees with superior characteristics. For want of a better designation it might be called *"method of the assumed norm"* since it has something of the character of the assumed mean, which it resembles as a convenient short cut in statistical analysis. The assumed norm has the advantage of being sufficiently self-correcting for use by rather inexperienced investigators (if that is really an advantage). In studying properties of wood it is valuable for detecting exceptional trees and thereby bringing them readily to critical attention.

Anatomical examination of wood of the aberrant trees that have been brought to attention by their deviation from the assumed norm will most readily decide whether the variant characteristic in question is principally a variation due to favorable environmental conditions of growth or is an inheritable characteristic that might be propagated through seed. In the one case the aid of the physiologist and silviculturist might be particularly indicated whereas in the other the aid of geneticists and tree breeders could be sought.

APPRAISAL OF "FIBER-LENGTH"

Tree breeders hope to discover genetic strains of hardwoods with abnormally long fibers for their species so that trees with this exceptional characteristic may be used to stock plantations. Compared with the softwoods used for pulp which have fibers that are upwards of 4 mm. long, the fibers of hardwoods are relatively short, being much less than half this length in most species. In the anatomist's scale of fiber-length, hardwood fibers less than 1 mm. long are classified as "very short"; over 1, but less than 1.5 is "short"; over 1.5, but less than 2 is "long"; and over 2 mm. is "very long" (*25*).

In a list of measurements of average fiber length reported for over 70 North American hardwoods (*4*) the over-all averages is "short," being about 1.4 mm. Of the dozen species over 1.5 mm. classifiable as "long," those of commercial significance are a species of *Magnolia* and the closely related yellow poplar (*Liriodendron*), red gum, and tupelo, while only one classes as "very long." This is black gum, of the same genus as tupelo, which tops the list in a class by itself at 2.3 mm.

The pattern of variation in fiber length normally encountered in a tree is to find that the fibers are shortest in the first central rings around the pith, but ever longer in successive rings, up to about the 50th, after which the tree appears to have reached its approximate capacity for producing cells of mature dimensions, although slight increase in length is detectable in some species up to about the 100th ring (*13, 17*). The variation is particularly noticeable in softwoods which begin life in the first annual ring with "fibers" less than a millimeter long, increasing rather quickly in subsequent rings until, on reaching a diameter of about 4 in., the young tree is producing fibers over 3 mm. The

rate of diameter increase is important, because rapidly grown plantation trees are generally capable of producing longer fibers for their age than the more suppressed trees of forest stands. Figure 8, showing the variation in length of tracheids measured in a forest-grown softwood, is attached, as this is a much more spectacular indication of the normal pattern of variation than can be shown in Canadian hardwoods, which begin with fibers less than 1 mm. in the first ring and reach their "mature" length by smaller annual increases, because their maximum is so much shorter than that of softwoods. In a yellow birch of some 16-in. diam. tested at the Ottawa Laboratory, F.P.L. of C., fibers at the first ring averaged less than 1 mm., but in the 30th ring (at 4-in. diam.) a fiber length of 1.2 mm. was recorded, and, at age of 60 years, the average was slightly under 1.5 mm., which appeared to be the maximum. It is of interest that a much higher average fiber length, 1.7 (with maximum 2.1) has been reported for a tree of yellow birch (*20*), an encouraging fact for tree breeders searching for genetic strains with long fibers.

CELL DIAMETERS

The diameter of prosenchyma cells follows much the same pattern of variation as the length, being typically small in the first rings and reaching mature dimensions apparently at the same age as the mature length becomes established. Figure 3 showing the pith and first 10 rings of a yellow birch tree illustrates the gradual increase in diameter of vessels from the juvenile minimum diameter in the first few rings. The larger vessels shown in Fig. 4 are from the 70th to 76th rings of the same log shown in Fig. 3. For purposes of identification anatomists have adopted the following general classification for the range in diameter of hardwood vessels as measured in mature wood (*5*).

Range of Diameter Classes of Vessels

Tangential diameter, μ	*Class designation*
Less than 25	Extremely small
25 to 50	Very small
50 to 100	Moderately small
100 to 200	Medium size
200 to 300	Moderately large
300 to 400	Very large

Such a scale may be convenient for general reference. By such classification, vessels of aspen, beech, basswood, buckeye, gum tupelo, and most maples would be moderately small; those of birch, broadleaved maple, and some of the larger cottonwood vessels would be medium; those of such native ring-porous woods as chestnut, elm, and oak, moderately to very large. No North American commercial species has vessels wider than 0.04 mm.

Vessel segments are typically shorter than the fibers of their species, and those of the largest diameters are shorter than the small ones. The length of extremely large vessels is typically less than the diameter. For this reason the wider vessels are not considered very significant in contributing to the properties of paper, although the very small ones may be more nearly comparable to fibers in this respect. Dimensions of all cellular elements of branches are typically smaller than in the main trunk of hardwood trees.

The variation in cell dimensions within the tree emphasizes the importance of selecting mature trees for sampling whenever information fully representative of a species may be required.

SUMMARY

Indicating the anatomical types of hardwoods and the principal patterns of anatomical variation in hardwoods, this paper has necessarily dealt with the obvious relationship between the structure of wood and its technological properties relating to pulp and paper. In view of widespread attention devoted to growing trees selected for desirable technological characteristics of wood, a method of anatomical appraisal has been suggested as a logical method of insuring and facilitating recognition of trees particularly desirable for insuring propagation of stock with qualities of wood most required for industrial uses.

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An Evaluation of Vacuum Pump Drive Capital Costs

E. J. JUSTUS and JOHN EBERHART

Vacuum requirements for a 276-in., 2500 f.p.m. suction pickup news or kraft machine were specified. Vacuum pumps of different manufacturers were selected, and drives of various types were selected for the different vacuum pumps plans. The relative costs of these drive plans are then compared. Evidence indicates that a relatively wide range in costs is possible on any given machine. Special advantages of steam turbines in some instances are pointed out.

THIS study was undertaken as a result of discussions in the Electrical Committee of TAPPI. The vacuum requirements for modern, large, high-speed paper machines have increased to the point where the power demands of the pumps approach or exceed that of the machine itself. Because of the increased magnitude of the vacuum pump drive costs, they are worthy of investigation.

There are many different types of pumps and usually several ways of driving each type that should be considered. Taking into account the various kinds and sizes of paper machines, also presents an impossible task of covering all situations or even a fair share of them. We have instead taken a representative machine of modern size and make-up and worked out for this machine most of the practical arrangements available today. Many of the points shown up in the study of this example will be transferable in relative order of magnitude to other machines and installations.

For the example we have chosen the 276 in. newsprint or kraft paper machine shown in Fig. 1. The vacuum requirements have been specified as follows:

	Vacuum level	*10 in. Hg*	*15 in. Hg*	*20 in. Hg*
Item 1	Flat boxes	1230 c.f.m.	...	...
Item 2	Couch wet box	2600 c.f.m.	...	...
Item 3	Couch dry box	...	...	10,400 c.f.m.
Item 4	Pickup roll	...	...	5,200 c.f.m.
Item 5	Suction wringer	...	5,700 c.f.m.	...
Item 6	1st transfer press	...	...	3,920 c.f.m.
Item 7	2nd press	...	...	6,260 c.f.m.
Item 8	3rd press	...	7,110 c.f.m.	...
Item 9	Felt conditioners	...	1,260 c.f.m.	...
Totals		3830 c.f.m.	14,070 c.f.m.	25,780 c.f.m

Figure 1 was sent to the following vacuum pump manufacturers for their recommendations of pumps and power requirements to supply the vacuum requirements: (1) Ingersoll-Rand, (2) Roots-Connersville, (3) Sulzer Brothers, and (4) Nash Engineering.

The vacuum pump manufacturers were informed of the purpose of the study and encouraged to offer various arrangements of pumps that might offer advantage or illustrate a point. Therefore, we believe that the arrangements shown are representative of the best available pump selections for the subject machine.

In selecting motors and controls for the different types of vacuum pumps, the vacuum versus power characteristics must be taken into account.

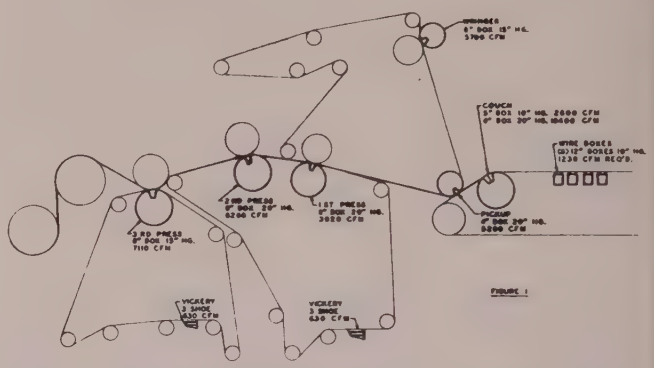

Fig. 1. Vacuum pump application for comparative costs of driving vacuum pumps—kraft or newsprint machine 2500 f.p.m.—276-in. wire

There are three different types of vacuum pumps in common use today. They are: (1) water ring pumps, such as Nash; (2) positive displacement-type pumps, such as Roots and Ingersoll-Rand; (3) centrifugal pumps, like Sulzer and Ingersoll-Rand. Each of these three types of pumps has markedly different horsepower versus vacuum characteristics. Referring to Fig. 2, it can be seen with the water ring pump, horsepower is very nearly constant throughout the vacuum range. It is relatively easy to choose the horsepower

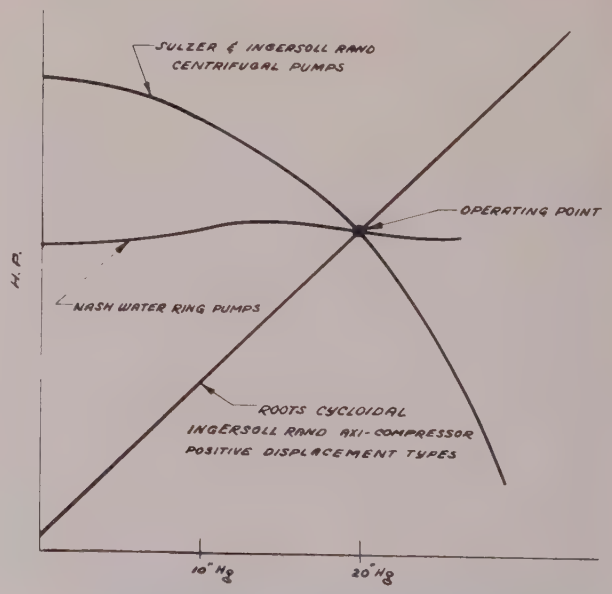

Fig. 2. Characteristic curves for h.p. vs. vacuum for different types of vacuum pumps

E. J. JUSTUS, Vice-President in Charge of Research, and JOHN EBERHART, Application Engineer, Beloit Iron Works, Beloit, Wis.

required to drive such a pump—take the maximum horsepower shown on the curve and you will be correct. It does mean that pumps must be supplied with motors which are capable of pulling the pump into step with full torque on the motor or else an auxiliary means must be used to lower the curves during starting. These pumps can be furnished with "unloaders" which will permit synchronous motors with normal pull-in torque to be used for starting. Without the "unloaders," full load pull-in torque must be supplied.

With the centrifugal pumps, as the vacuum increases, the horsepower drops. For such pumps it is necessary when the sheet is off the machine and there is little throttling by the sheet of the inlet of the pump, that artificial throttling be provided. Otherwise, a very large horsepower motor would have to be provided which would not be loaded appreciably under running conditions. The shape of this curve reflects the fact that centrifugal pumps are essentially constant pressure ratio pumps. With artificial throttling controls on the inlet side of centrifugal pumps, the motor is selected for ample horsepower for the running range for a selected minimum vacuum and maximum flow. The automatic throttling controls are essentially overload limiters. There is no danger on a centrifugal pump with motor overload from running heavier sheets or closer felt than was normally selected, or if the pump has been selected a little bit on the large side and the vacuum goes higher than expected. Under such conditions the motor is perfectly all right because actually the horsepower requirements will have dropped with greater inlet vacuum.

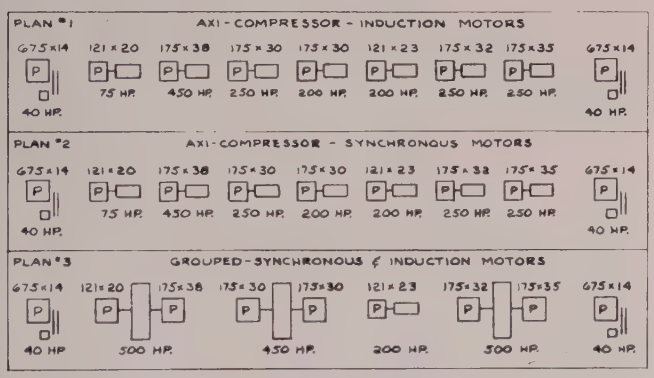

Plate 1. Ingersoll-Rand

On the other hand, the Roots or cycloidal-type pump has an entirely different type of characteristic. The horsepower increases with the vacuum, and at very low vacuums with no sheet on the machine, the power requirements are very low. On Roots or Ingersoll-Rand positive displacement pumps, starting with the sheet off the machine is little or no problem. However, if these pumps have been selected to be a little larger than necessary, resulting in a higher vacuum than was normally expected, the power requirements on the motor will go up. If the vacuum rises above that for which the motor horse-power was selected, automatic bleeding valves should be supplied to bleed air into the inlet side of the vacuum pump to hold the maximum vacuum to a specified level.

Thus, on the three pumps, we have the water ring pump with essentially constant horsepower requirements throughout the vacuum range, centrifugal pump with a decreasing horsepower requirement with increase in vacuum, and the cycloidal pump with increasing horsepower requirement with an increase in vacuum level. The water ring and centrifugal pumps demand full load torque or more on starting without auxiliary control, and the positive displacement pumps can demand increased power under operating conditions if vacuum increases. The horsepower versus vacuum characteristics of the vacuum pump must be considered when selecting vacuum pump drives.

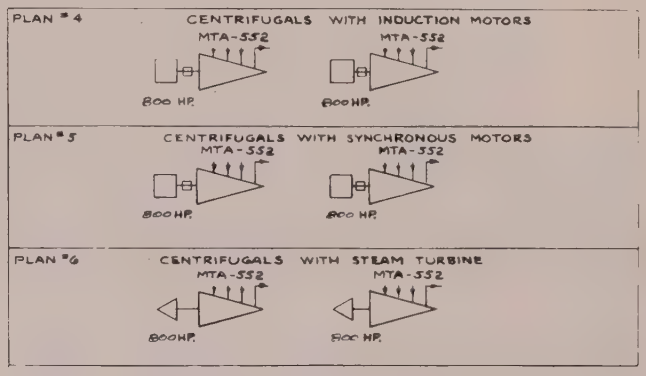

Plate 2. Ingersoll-Rand

Using a standard set of rules and the best pricing information available to us, we selected 27 different practical drive arrangements for the vacuum pumps on the machine and totaled up the capital costs of the drives. Prime mover, couplings, gears, starters, belts, and shafts were included. All motors, sizes up to and including 200 hp, both induction and synchronous, are 440 v., 3 phase, 60 cycle. Motors 201 hp. and up are 2300 v., 3 phase, 60 cycle. All motor prices are from

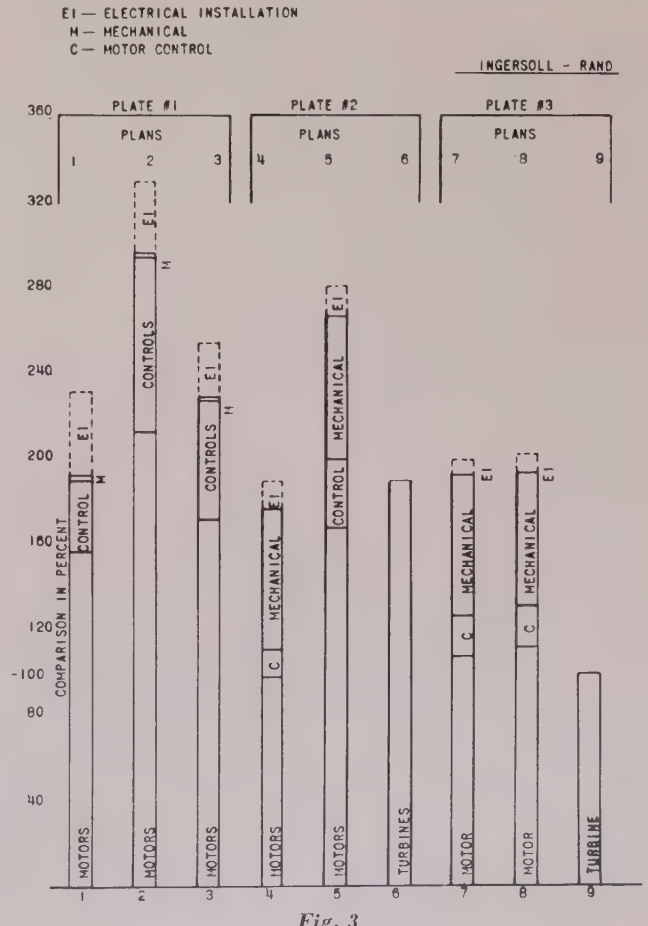

Fig. 3

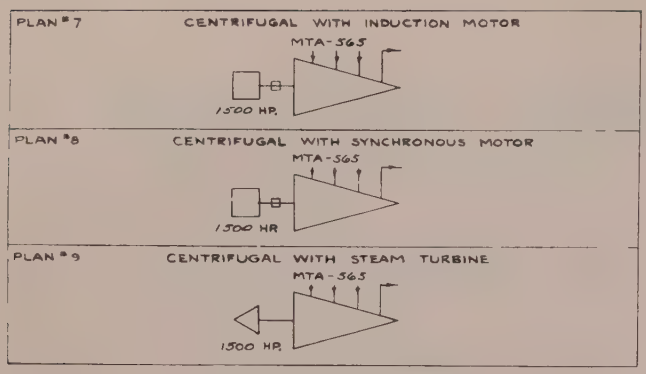

Plate 3. Ingersoll-Rand

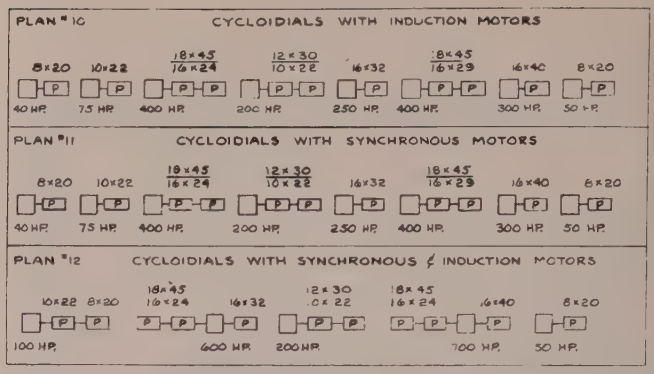

Plate 4. Roots Connersville

the latest catalog of a large electrical manufacturer, with appropriate mill discount figures used. All synchronous motors are picked at unity power factor. We have taken the stand that power factor correction should be purchased on the basis of its own merits and should not be confused with the cost of driving vacuum pumps.

Controls or starters up to and including 200 hp. are across-the-line magnetic motor starters of general purpose construction, including a remote push button. Above 200 hp., the starters are full voltage, 2300 v., single speed, nonreversing, with 10 times full load current interrupting capacity. The synchronous starters are full voltage, 10 times full load interruption capacity, enclosed, floor mounted, nonreversing for 440 v., motors up to 200 hp. and for the 2300 v. motors over 200 hp. Exciters have been selected to be either belt driven or direct mounted, whichever was the least costly for a given installation.

During the study, it became evident that in many cases steam turbines would also make a very practical drive for certain installations, and the basis of selection for the steam turbines has been 550 p.s.i.g. inlet pressure, 110°F. superheat, and 150 p.s.i.g. back pressure.

It will be noted on some of the centrifugal compressors that mechanical costs run rather high. This shows the inclusion of speed increasers where electric motors have been used. The mechanical cost also includes necessary couplings, belts, shafting, etc., for a given installation. Gear costs have been taken from a catalog of a well-known manufacturer.

We should also explain that we have not here made a direct comparison between drive costs of different manufacturers' pumps. This study is made on the following basis. Assuming the pumps have been selected, what are the relative drive costs of various plans to drive a given manufacturer's pumps? The lowest cost drive plan for each pump manufacturer is taken as 100% and the other drive plans for this manufacturer compared on a percentage basis.

For a new mill, considerable savings in capital costs may be possible if steam is brought to the paper machine at generated pressure of approximately 600 p.s.i. and used to drive the vacuum pump turbine direct, with the exhaust going to the machine header. The alternative may be to purchase the necessary vacuum pump turbine power for the power house, the alternator capacity, the transformer capacity, the starter capacity, and the motor capacity for the vacuum pumps plus electrical transmission lines.

We are not trying to make a case for steam turbines, but where the source of energy is fuel or high pressure steam, the capital costs of using the steam directly in a turbine at the load, versus electrical transmissions from a remote turbine should be thoroughly investigated.

On plate 1 we have the offerings of the Ingersoll-Rand Co. using positive displacement-type compressors with some internal compression. Plan 1 shows the pumps direct driven with induction motors and with a maximum number of pumps.

Plan 2 shows the same arrangement of pumps as plan 1 but with synchronous motors used.

Plan 3 shows a grouping of the pump and motors to arrive at a minimum number of components, with both synchronous and induction motors used as indicated by lowest price.

On plate 2 is shown the Ingersoll-Rand Co. centrifugal vacuum pumps. Of the various plans shown here, plans 4 through 6 shows two identical centrifugal vacuum pumps capable of supplying the requirements for the machine. There are three ways of driving these two vacuum pumps: with induction motors, synchronous motors, or with steam turbines. These vacuum pumps have multiple inlets as shown. They are

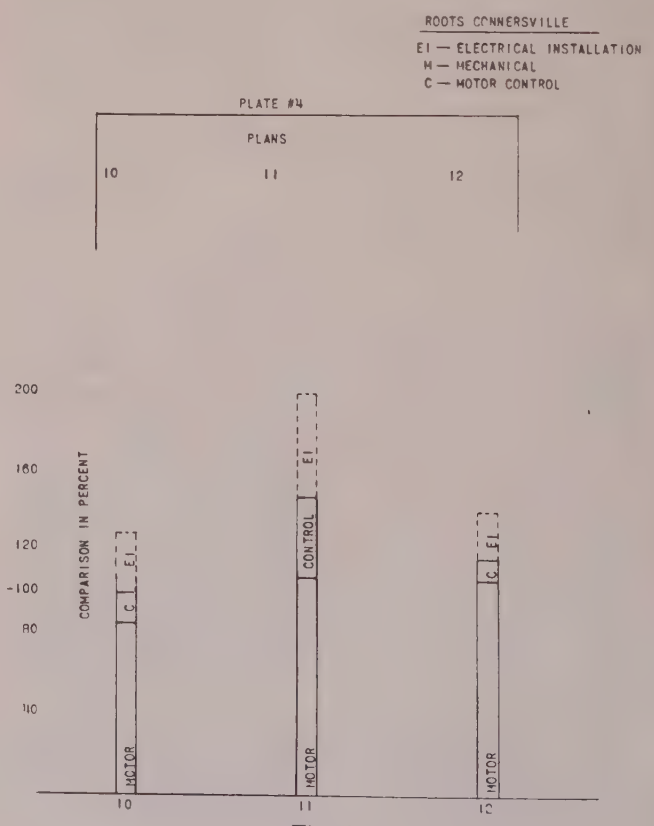

Fig. 4

multistage centrifugal pumps. The vacuum level is different in each stage, and the inlet to each stage is made in accordance with the level of the vacuum required.

Plate 3 shows plans 7 through 9 which are indicative of a large single centrifugal blower capable of supplying the entire vacuum requirements for the machine. This large centrifugal blower with multiple inlets can also be driven with an induction motor, a synchronous motor, or with a steam turbine.

The bar graph shown in Fig. 3 compares the relative costs of the different Ingersoll-Rand vacuum pump drive plans. It can be seen that the least expensive from the first cost point of view is steam turbine drive for the large centrifugal vacuum pump. In many cases, this could also be a very practical arrangement for the mill. There are people who refer with horror to this so-called "putting all of your eggs in one basket" type of thing on paper machines; however, it should be kept in mind that on any paper machine installation, the "eggs," so to speak, are in many concentric baskets, and failure of any one of these baskets results in a shutdown, so that what is required is a maximum of reliability of any of the components which will cause shutdown. This can be a single drier bearing, a couch bearing, a shell, a felt roll, a felt, fan pump, a squirt pump, or what have you, any of which will cause a shutdown on the machine.

It would appear that if positive displacement pumps from Ingersoll-Rand are to be used, plan 1 would be the most advantageous. If the centrifugal pumps are to be used, certainly plan 9 with its obvious advantages in first cost should be considered seriously. There could be a considerable amount of spare parts placed in the mill for the single drive unit of plan 9 as compared to using the double turbine arrangement for plan 6 with no spare parts.

Referring to Plate 4, Roots-Connersville Blower Co. has offered a single arrangement of pumps for which we have selected three different drive plans. Plan 10 uses induction motors. In plan 11 the pumps are driven with synchronous motors, and with plan 12 we have grouped the pumps so as to permit the use of the largest motors possible. This grouping is with the consent of the pump manufacturers.

Figure 4 shows the relative cost of the different drive plans for the Roots-Connersville arrangement, indicating that the initial grouping in plan 10 with the induction motors is the least expensive. However, it is possible to use synchronous motors and obtain a smaller number of motors with plan 12. Perhaps the first choice for most mills would be plan 10 with the induction motors which would offer the maximum simplicity in motors and in control equipment with a maximum of flexibility.

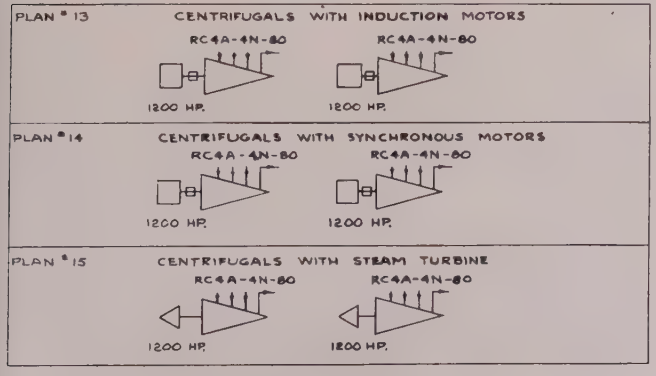

Plate 5. Sulzer

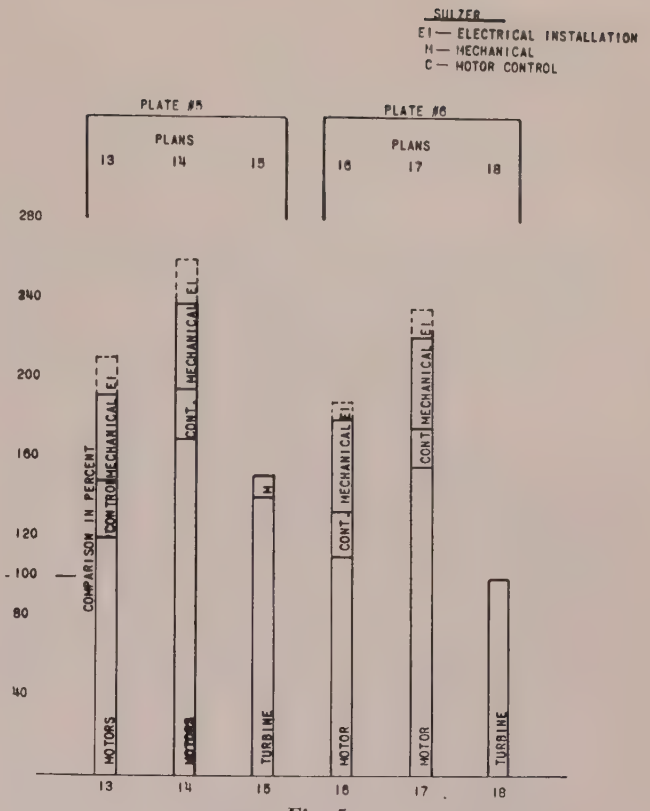

Fig. 5

In plates 5 and 6 are shown pumps submitted by Sulzer Brothers of Switzerland. Although Sulzer pumps are not used extensively in this continent, they are used very extensively in Europe and have proved themselves to be a very practical means of providing vacuum requirements for large paper machines. The first three plans, plans 13 through 15, show duplicate Sulzer pumps to provide the requirements for our subject machine. In driving these pumps, we have used the manufacturer's selection of motor horsepowers. Sulzer has been quite conservative in selecting the motor horsepower as compared to the running horsepowers required on the pumps. Plan 13 has two induction motors; plan 14, synchronous motors, each with step-up gears; and in plan 15, direct drive steam turbines are used.

Sulzer Brothers also build large single centrifugal blowers capable of supplying a machine of this size. In plan 16 the blower is driven with an induction motor; plan 17, with a synchronous motor; plan 18, with a steam turbine. Sulzer blowers are multistage centrifugal pumps, and the inlet to the pump is made at the appropriate stage for the vacuum requirement.

In Fig. 5 the comparative costs of the various Sulzer arrangements are shown; and plan 18 with the large single turbine direct driving into the large single blower, shows the minimum of cost. The next lowest cost is the multiple or double blower arrangements of the turbine, and then the various electrical arrangements. The large mechanical costs shown in the electrical arrangements are for the step-up gears required. All six of these plans are in use in one mill or another and represent practical drive arrangements. As was seen in the Ingersoll-Rand plans, direct driving of Sulzer pumps with a steam turbine can be very attractive, particularly if the steam balance is right.

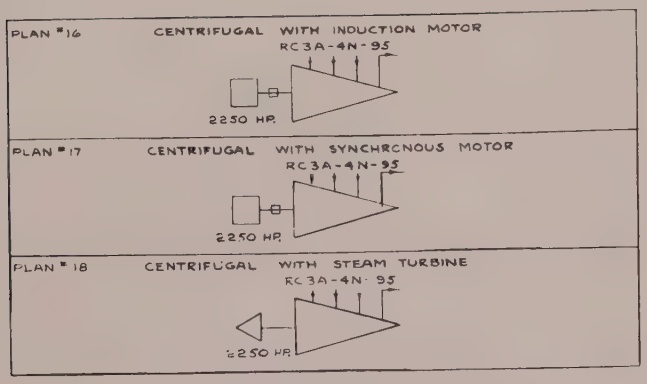

Plate 6. Sulzer

Plate 7 shows three ways of driving a given group of Nash pumps capable of supplying the specified machine. Nash water ring vacuum pumps have had a very wide acceptance in the paper industry for many years. There are many ways to group or drive them, some of which are shown here.

Plan 19 has individual synchronous motors with the rotors directly mounted on the extended shafts of the pumps. This is a practical drive and has been used quite frequently although the first cost is high.

Plan 20 shows V-belt drives to induction motors. This arrangement has been used extensively over the years. Perhaps the best thing that can be said is that it has maximum flexibility in that pump speeds may also be altered by changing pulleys to more nearly match pump to vacuum requirements. However, this is usually interpreted to mean the fastest pump speed that won't overload the motor.

Plan 21 is the same with synchronous motors. This arrangement also has been used extensively.

Plan 22 on Plate 8 shows arrangements of Nash pumps with built-in gears to reduce the drive costs associated with the necessarily low revolutions per minute of water ring pumps. Motors, of 1750 or 1800 r. p. m., with double extended shafts are placed in between two pumps and connected to the high-speed shaft of the reducer on each pump. This arrangement also permits a reduction in the control costs by reducing the number of motors.

Plan 23 is like 22 except synchronous motors are used.

It is interesting to note later in the comparative costs that plans 22 and 23 are almost equal in cost. These motors and control are right at the cross-over point where synchronous motor and induction motor drives cost the same. At higher horsepowers, the synchronous motors are cheaper.

Plan 24 is most interesting in that it is quite a de-

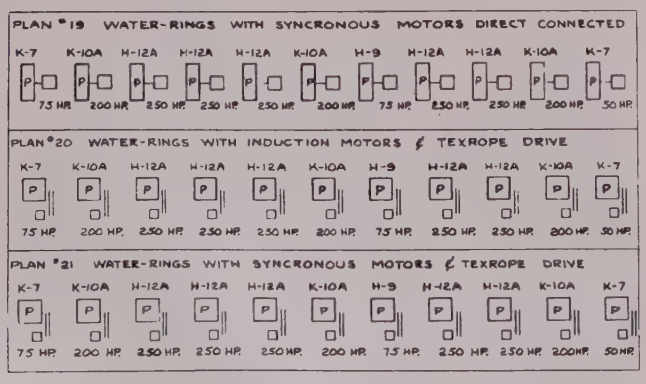
PLAN #19 WATER-RINGS WITH SYNCRONOUS MOTORS DIRECT CONNECTED
K-7 K-10A H-12A H-12A H-12A K-10A H-9 H-12A H-12A K-10A K-7
7.5 HP. 200 HP. 250 HP. 250 HP. 250 HP. 200 HP. 7.5 HP. 250 HP. 250 HP. 200 HP. 50 HP.
PLAN #20 WATER-RINGS WITH INDUCTION MOTORS & TEXROPE DRIVE
K-7 K-10A H-12A H-12A H-12A K-10A H-9 H-12A H-12A K-10A K-7
7.5 HP. 200 HP. 250 HP. 250 HP. 250 HP. 200 HP. 7.5 HP. 250 HP. 250 HP. 200 HP. 50 HP.
PLAN #21 WATER-RINGS WITH SYNCRONOUS MOTORS & TEXROPE DRIVE
K-7 K-10A H-12A H-12A H-12A K-10A H-9 H-12A H-12A K-10A K-7
7.5 HP. 200 HP. 250 HP. 250 HP. 250 HP. 200 HP. 7.5 HP. 250 HP. 250 HP. 200 HP. 50 HP.

Plate 7. Nash

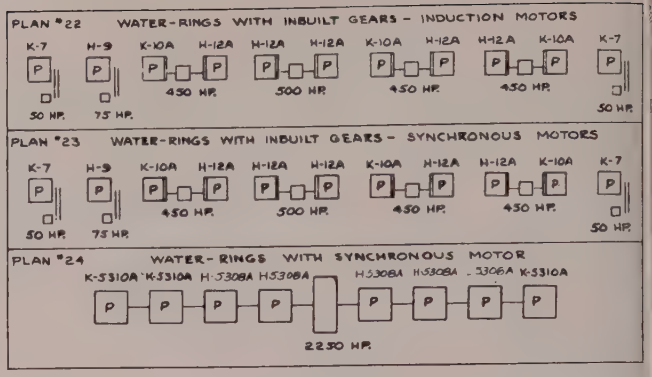
PLAN #22 WATER-RINGS WITH INBUILT GEARS - INDUCTION MOTORS
K-7 H-9 K-10A H-12A H-12A H-12A K-10A H-12A H-12A K-10A K-7
50 HP. 7.5 HP. 450 HP. 500 HP. 450 HP. 450 HP. 50 HP.
PLAN #23 WATER-RINGS WITH INBUILT GEARS - SYNCHRONOUS MOTORS
K-7 H-9 K-10A H-12A H-12A H-12A K-10A H-12A H-12A K-10A K-7
50 HP. 7.5 HP. 450 HP. 500 HP. 450 HP. 450 HP. 50 HP.
PLAN #24 WATER-RINGS WITH SYNCHRONOUS MOTOR
K-5310A K-5310A H-5308A H-5308A H-5308A H-5308A K-5310A
2250 HP.

Plate 8. Nash

parture from past practice and at the same time has proved to have many advantages. One, large, low speed, synchronous motor with double extended shaft is placed in the center of a line of eight pumps. The pumps have double extended shafts and are capable of transmitting the necessary through horsepower. A jack shaft is also provided to temporarily take the place of any pump removed from the line.

This arrangement is also looked on with disfavor by by the "eggs in one basket school," but we are reminded of the fellow who said, "An airplane with four engines that won't fly on any three is an unnecessary complication."

With the single large motor, a maximum of protection in the way of relays, thermal guards, and enclosures can be provided. Also, there is the diversification of load on the pumps which permits one pump to overload without overloading the motor.

We have been a party to an installation like plan 24 which has been in operation over a year. It has given completely trouble-free service.

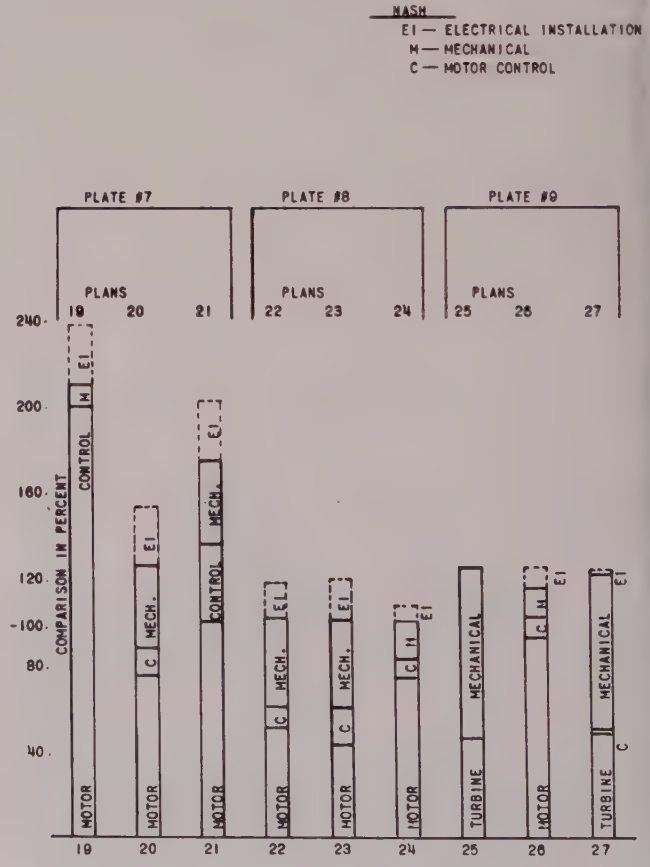

Fig. 6

Plan 25 is the same as 24 except that the large synchronous motor has been replaced with a turbine and gear. Again, the turbine must be considered in view of

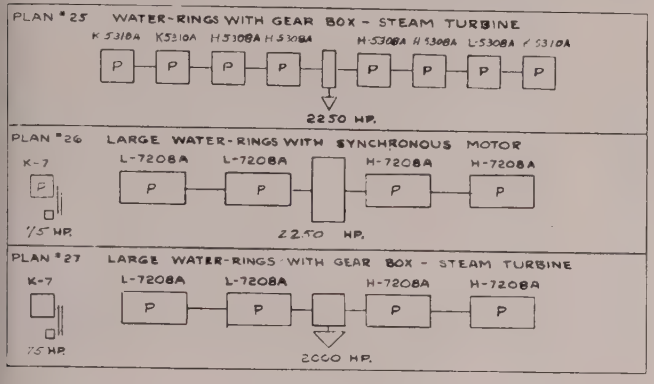
PLAN #25 WATER-RINGS WITH GEAR BOX - STEAM TURBINE
K-5310A K-5310A H-5308A H-5308A H-5308A H-5308A L-5308A L-5310A
P P P P P P P P
2250 HP.
PLAN #26 LARGE WATER-RINGS WITH SYNCHRONOUS MOTOR
K-7 L-7208A L-7208A H-7208A H-7208A
P P P P P
75 HP. 2250 HP.
PLAN #27 LARGE WATER-RINGS WITH GEAR BOX - STEAM TURBINE
K-7 L-7208A L-7208A H-7208A H-7208A
P P P P P
75 HP. 2000 HP.

Plate 9. Nash

the steam balance of the mill and operating conditions. On some installations, and particularly on kraft board, the turbine drive should be very attractive. There is also the possibility of variable speed drive from the turbine.

Plan 26 and plan 27 are variations using large synchronous motors or a turbine to drive the new large size Nash pumps. In this case the cost is somewhat more than plan 24 because of the lower speed.

Figure 6 is a comparison of the different drive costs for Nash pumps.

It is interesting here that plan 24, which we believe to be one of the best arrangements possible, is also the cheapest. It seldom happens this way. Plans 22 and 23 are interesting, and the turbine plans 25 and 27 have their special interest. From the results of this study, it would appear that individual motor drives for Nash pumps are an expensive luxury.

Again, let us say that the purpose of this study is to show by a specific example some of the relative costs of vacuum pump drive arrangements and to discuss some of the factors affecting cost. It is hoped that with this background, mill engineers will have a broader base of understanding and examples to choose from in selecting future vacuum pump drive schemes.

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The Effect of Pulp History on Pulp Response During Hypochlorite Bleaching

J. C. PAULSON

The reaction between sulphate pulp and hypochlorite may be simplified by treating it as a cellulose depolymerization reaction in which the lignin and hemicellulose fractions compete for hypochlorite usage. Thus, the effects of pulp history and the accompanying changes in the lignin and hemicellulose fractions are shown by the sparing action on the cellulose fraction. The change in cellulose D.P. is estimated by measuring the change in pulp fluidity per unit of hypochlorite consumed, $d\phi/dx$. A further simplification is obtained by splitting the total reaction into two parts, the so-called initial rapid reaction and the slow reaction. The magnitude of the initial reaction depends upon the amount of lignin in the pulp, and, with lignin the main substrate, there is only a slight influence on cellulose D.P. During the slow reaction the pulp fluidity increases as a linear function of the amount of bleaching agent consumed; however, the magnitude of $d\phi/dx$ is influenced by two competing substrates, the amount of lignin solubilized during the initial reaction and the amount of hemicellulose in the pulp.

THIS report, which is a continuation of a previous report (*1*), deals with some of the chemical aspects of hypochlorite bleaching of pine sulphate pulp.

In the production of dissolving pulp, the pulp-hypochlorite reaction is regarded as both a delignification and cellulose depolymerization step. In studying such a reaction one can make certain assumptions: (1), there are at least three pulp fractions which can compete for hypochlorite during the reaction—lignin, cellulose, and hemicellulose; (2), the three fractions, as a result of differences in their relative amounts, chemical structures, and physical accessibilities, will differ in their reactivities toward hypochlorite; and (3) the reactivities of the various fractions will be subject to change during the pulping and bleaching steps.

The purpose of this work is to demonstrate the role of the various pulp fractions during hypochlorite bleaching, and to show, in a few instances, the effect of pulp history on the response of the various pulp fractions.

EXPERIMENTAL

Pulps

Pulps were prepared from southern pine by the sulphate process both with and without prehydrolysis. The pulps were semibleached by acid chlorination followed by a hot caustic extraction. Fully bleached pulps were prepared by delignification with acidified sodium chlorite.

Hypochlorite Reaction Procedure

The hypochlorite reaction conditions were the same as previously described (*1*). The reaction was carried out with 2-g. pulp samples at 2% consistency and buffered with 0.3*M* Na_2CO_3 (pH 11). The use of sodium carbonate as a buffer during hypochlorite bleaching has been described by Alfredsson (*2*). The reactants were mixed throughout the reaction with a shaking device, and at the end of the reaction period the residual hypochlorite was measured *in situ* by

J. C. PAULSON, Senior Research Chemist, Buckeye Cellulose Corp., Memphis, Tenn.

iodometric titration. The washed pulps were made into TAPPI handsheets, and after brightnesses were recorded the viscosities were measured at 0.5% concentration in cupriethylenediamine.

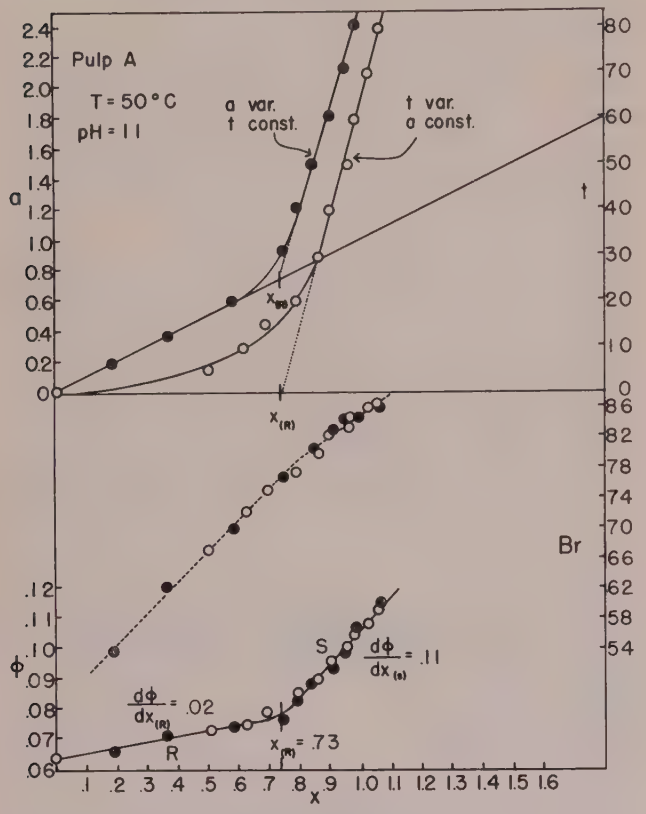

Fig. 1. The effect of reaction time and initial hypochlorite level on pulp hypochlorite response

Analyses

Pulps were analyzed for monomeric sugars (glucose, mannose, and xylose) by paper chromatographic separation and direct densitometry (*3*).

Pulp brightness measurements were made using the Beckman DU spectrophotometer with reflectance attachment. All brightness readings are uncorrected Beckman reflectance readings.

Symbols

The following symbols are used:

- a = initial hypochlorite level, % as Cl_2 on the pulp.
- x = hypochlorite consumed, % as Cl_2 on the pulp.
- t = reaction time, minutes.
- ϕ = pulp fluidity, reciprocal of 0.5% CED viscosity.
- Br = Beckman pulp brightness.
- $x_{(R)}$ = hypochlorite consumed by the pulp during the initial rapid reaction.
- $d\phi/dx$ = change in pulp fluidity per unit of hypochlorite consumed. Subscripts (S) and (R) indicate slow or rapid portion of the reaction.

Hypochlorite Reaction Temperature

It has been shown (*1*) that the course of the hypochlorite reaction is strongly temperature dependent, i.e., the various pulp fractions have different temperature coefficients with respect to hypochlorite. Therefore, in comparing pulp samples of different histories it is necessary to maintain a fixed hypochlorite reaction temperature. For purposes of convenience, hypochlorite reaction temperature was maintained at 50°C.

Effect of Initial Hypochlorite Level and Reaction Time

Figure 1 shows the response of a semibleached prehydrolyzed pulp (chlorination plus caustic extraction) during treatment with hypochlorite with variations in initial hypochlorite level and reaction time. Two sets of reaction conditions were used: (1) the initial hypochlorite level was held constant at 2.44% and replicate samples were withdrawn at time intervals; (2) reaction time was held constant at 60 min and the initial hypochlorite level was varied from 0.19 to 2.44%. The amount of hypochlorite consumed by the pulp, x, was plotted against the initial hypochlorite level, a, if reaction time, t, was held constant, or if a was held constant then x was plotted against t. Pulp fluidity, ϕ, and brightness, Br, were plotted against x for each set of conditions.

Figure 1 shows that the course of the reaction in terms of pulp brightness and fluidity versus the amount of hypochlorite consumed is independent of the initial hypochlorite level or reaction time within the limits studied, and it is possible to draw common fluidity and brightness curves for both sets of conditions. This experiment was carried out to determine whether running the reaction with variable a and constant t would be comparable to the more conventional method of fixed a and variable t. The former method is much easier to use since it enables one to more accurately measure the amount of hypochlorite consumed, particularly at low levels. Thus, in the following experiments the variable a — fixed t method is used.

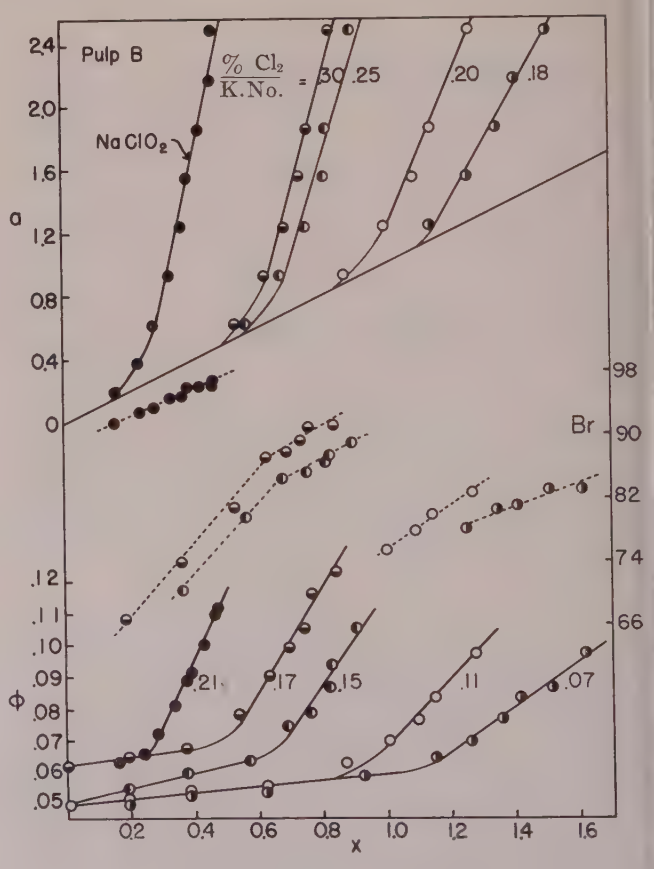

Fig. 2. The influence of level of delignification prior to the hypochlorite stage

Method of Handling Data

As shown in Fig. 1, the plot of a versus x shows the initial period during which all of the added hypochlorite is consumed during the 60-min. reaction period; beyond this point an excess of hypochlorite accumulates in proportion to the initial hypochlorite level. In the t versus x plot a similar effect is shown, i.e., the rate of hypochlorite consumption diminishes after the first 20 min. or so of the reaction. The specific rate constant, of course, remains unchanged. By extrapolating the linear portion of both curves, the total reaction can be separated on the basis of stoichiometry into two parts, the initial rapid reaction, $x_{(R)}$, and the slow reaction.

The change in cellulose D.P. during the designated rapid and slow portions of the reaction is shown by the ϕ versus x plot. During the rapid reaction the pulp fluidity increase per unit of hypochlorite consumed is 0.02, while during the slow reaction $d\phi/dx$ increases to 0.11. There is a sharp break in the fluidity curve at the point designated $x_{(R)}$, the amount of hypochlorite

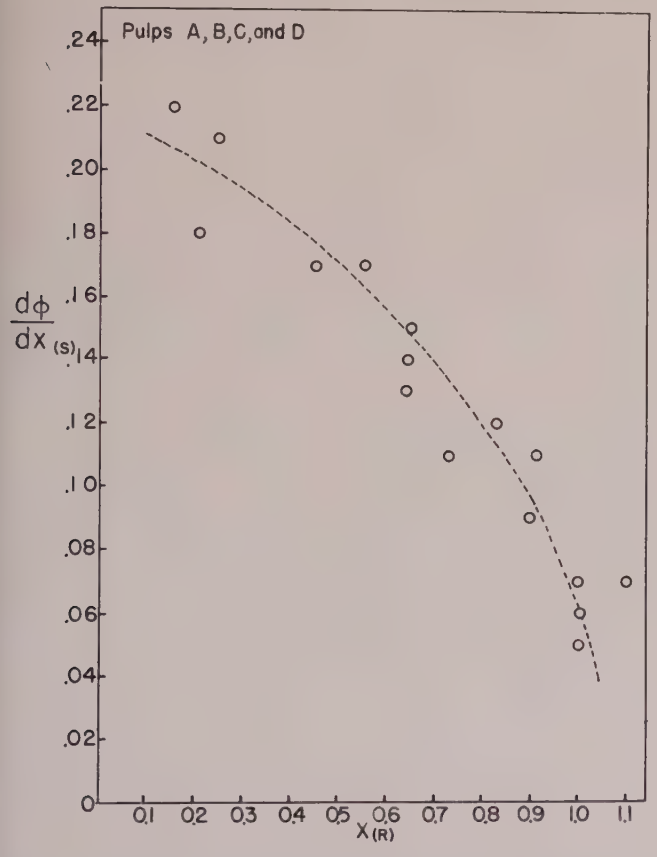

Fig. 3. Relationship between the amount of hypochlorite consumed during the initial reaction and the change in pulp fluidity during the slow reaction; prehydrolyzed wood pulps

consumed by the pulp during the rapid reaction. Agreement between $x_{(R)}$ values obtained by the two techniques is usually quite good.

In a manner similar to fluidity, the pulp brightness increase is not linear over the entire reaction. Brightness increase per unit of hypochlorite consumed is greater during the initial reaction than during the slow reaction. There is a slight lag between pulp brightness and the amount of hypochlorite consumed by the pulp since the pulp is thoroughly washed with water before the brightness handsheet is made. The washing treatment could conceivably remove additional lignin which has been only partially reacted with hypochlorite.

RESULTS

Effect of Level of Delignification Attained Through Bleaching Prior to the Hypochlorite Stage

The effect of chlorine level during the first stage of bleaching on the pulp response during the subsequent

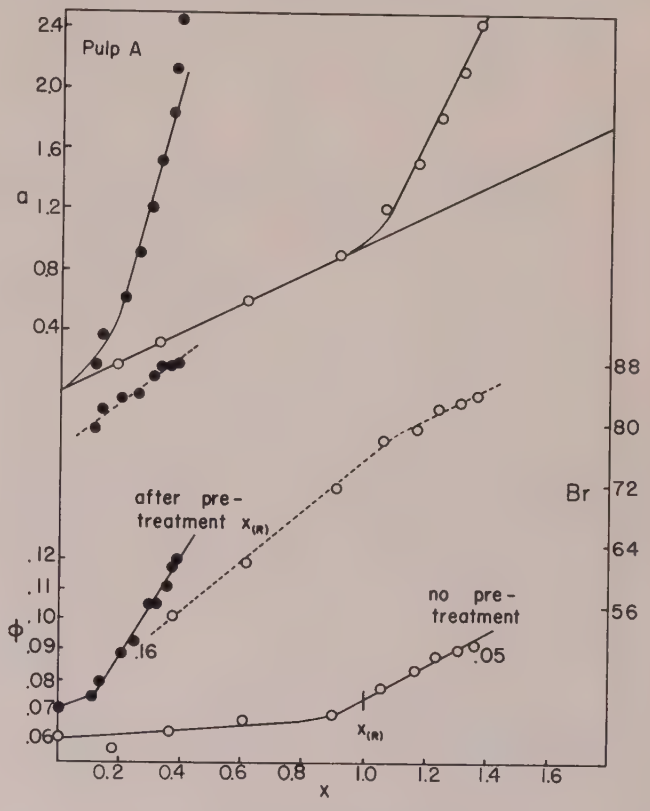

Fig. 4. The effect of hypochlorite pretreatment on pulp hypochlorite response

hypochlorite treatment is shown in Fig. 2. Samples of pulp B were reacted with chlorine water at 25°C. and 3% consistency for 1 hr.; this was followed by a caustic extraction at 50°C. and 10% consistency for 1 hr. with 3% NaOH on a pulp basis. The samples were then reacted with hypochlorite under the conditions previously described. One pulp sample was reacted with sodium chlorite in order to attain nearly complete delignification prior to the hypochlorite stage.

As chlorine level during the first stage of bleaching increases, the amount of hypochlorite consumed by the pulp during the initial rapid reaction, $x_{(R)}$, decreases. The maximum reduction in $x_{(R)}$ is attained with the chlorite delignified pulp. Since the initial rapid reaction is predominantly a lignin reaction, the decrease in $x_{(R)}$ is apparently the result of increasing delignification. This is also shown by the pulp brightness values. The change in pulp fluidity, $d\phi/dx$, during the rapid reaction is virtually the same for all of the pulps. More noteworthy is the effect of $x_{(R)}$ or lignin level on the change in pulp fluidity during the slow reaction. The slope, $d\phi/dx$ (S), shows a threefold increase in going from 0.07 to 0.21 as $x_{(R)}$ decreases from 1.1 to 0.25%.

Figure 3 clearly shows the inverse relationship between $x_{(R)}$ and $d\phi/dx$ (S). The data were collected from a series of four pulps (A, B, C, and D) which contained different amounts of lignin as a result of either varying chlorine level or sodium chlorite level prior to the hypochlorite stage.

Effect of a Hypochlorite Pretreatment

Pulp A was first chlorinated and caustic extracted and then reacted with hypochlorite under the conditions

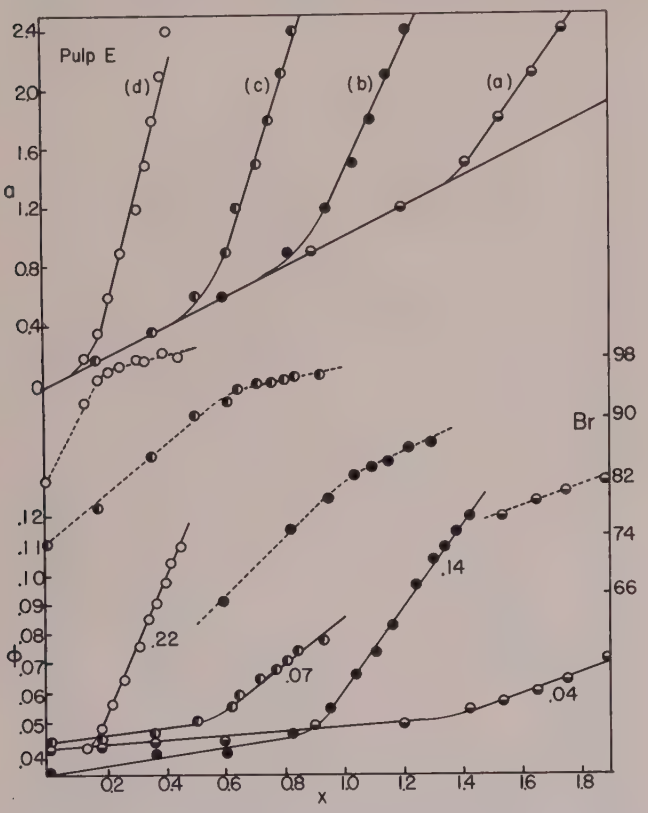

Fig. 5. The influence of hemicellulose on pulp hypochlorite response

	Pentosans, %	$x_{(R)}$, %	$d\phi/ds$ (S)
(a) Cl_2, CE	7.3	1.35	0.04
(b) Cl_2, CE, 100 g.p.l. NaOH[a]	2.4	0.90	0.14
(c) Cl_2, CE, $NaClO_2$	7.3	0.55	0.07
(d) Cl_2, CE, $NaClO_2$, 100 g.p.l. NaOH[a]	2.0	0.17	0.22

[a] 3% consistency, 40°C., 15 min.

previously described. The values $x_{(R)}$ and $d\phi/dx$ (S) were estimated graphically as shown in Fig. 4. A replicate sample of the semibleached pulp was given a hypochlorite pretreatment using an initial hypochlorite level corresponding to $x_{(R)}$ (1.0%). After all of the hypochlorite was consumed during the pretreatment, the pulp was thoroughly washed with water and then air dried. The sample was again reacted with hypochlorite and $x_{(R)}$ and $d\phi/dx$ (S) were measured. As shown in Fig. 4, $d\phi/dx$ (S) increases from 0.05 to 0.16 as a result of the hypochlorite pretreatment and washing of the pulp.

The hypochlorite pretreatment amounts to splitting the reaction into two stages which are separated by a water wash; the first stage consisting of the rapid reaction and the second stage comprising the slow reaction. It is apparent that the interspersed water wash has removed from the pulp and the liquid phase of the reaction mixture some soluble materials which, although they react with hypochlorite during the initial reaction, continue to consume hypochlorite during the slow reaction. This is indicated by the greater attack on the cellulose fraction during the slow reaction as a result of the washing treatment and the redistribution of

Table I. Pulp Types

Pulp	K no.	Monomeric sugars,[a] unbleached pulp Glucose	Mannose	Xylose
A	13.0	94.0	2.6	3.4
B	13.9	93.5	3.3	3.2
C	11.5	93.6	3.1	3.3
D	20.6	94.7	1.6	3.7
E	18.9	79.8	9.1	11.1

[a] Percentage of total sugars found on chromatogram.

hypochlorite usage among the pulp fractions. Since the initial reaction involves the lignin fraction, the soluble materials are apparently formed from lignin during the initial attack. The magnitude of the sparing action depends upon the amount of lignin available, thereby accounting for the inverse relationship between $x_{(R)}$ and $d\phi/dx$ (S) (Fig. 3).

Influence of Wood Prehydrolysis and Pulp Caustic Extraction

Pulp E differs from the other pulps in that it was isolated from a nonprehydrolyzed wood; therefore, it has more hemicellulose material than the other pulps. This is shown by a comparison of the pulp mannose and xylose levels in Table I. Figure 5 shows the hypochlorite response of this pulp at different lignin levels both with and without the removal of hemicellulose material by a strong caustic extraction.

The effect of hemicellulose material on $d\phi/dx$ (S) is quite pronounced. In the case of condition (c), in which the hemicellulose material has not been removed, the $d\phi/dx$ (S) value at an equivalent lignin or $x_{(R)}$ level is significantly lower than those shown in Fig. 3 for pulps derived from prehydrolyzed wood. Removal of hemicellulose material from the pulps by a strong caustic extraction, conditions (b) and (d), restores the slopes to levels equivalent to or higher than those for prehydrolyzed wood pulps. Comparison of (b) and (d) shows that although pulp (b) contains more lignin than (c), its $d\phi/dx$ value during the slow reaction is actually greater than that of (c), the difference apparently being due to the hemicellulose fraction.

The sparing action of the hemicellulose material on the cellulose fraction is probably similar to the effect of solubilized lignin, the mechanism involving a competing reaction, but there are probably other factors such as physical accessibility which are involved.

CONCLUSIONS

The pulp-hypochlorite reaction may be simplified by: (1) treating it as a cellulose depolymerization reaction in which the other pulp fractions, lignin and hemicellulose, compete for hypochlorite usage, thereby exerting a sparing action on the cellulose fraction; (2) separating the total reaction into two parts, the initial rapid reaction and the slow reaction.

The cellulose reaction is followed by measuring the change in cellulose D.P. as bleaching agent is consumed. Specifically, decrease in cellulose D.P. is estimated by measuring the change in pulp fluidity per unit of hypochlorite consumed, $d\phi/dx$.

The initial rapid reaction is predominantly a lignin reaction and reflects the level of delignification attained through bleaching prior to the hypochlorite stage, e.g., by altering chlorine level in the first stage of bleaching.

The magnitude of the initial rapid reaction affects the change in pulp fluidity during the slow reaction, presumably through the mechanism of solubilized lignin.

The pulp hemicellulose fraction also influences the distribution of hypochlorite among the other fractions; thus, prehydrolysis of the wood or strong caustic extraction of the pulp affect the pulp response during hypochlorite bleaching.

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Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

The Application of an Analog Computer to a Paper Manufacturing Problem

L. W. ZABEL

The machine direction temperature distribution on the surface of a Yankee drier manufacturing tissue has been calculated using the heat flow equation $\frac{\partial^2 T}{\partial x^2} = \frac{\rho Cp}{k}\frac{\partial T}{\partial s}$. This equation was solved on an analog computer by using the finite difference method. The partial differential equation was reduced to a set of 24 ordinary linear differential equations. The application of the special boundary conditions and data on driers made of two materials are given.

THE general purpose analog computer is rapidly gaining stature as a tool to aid in the solution of problems in the process industries. This device is particularly well adapted to the solution of dynamic problems in which time is the independent variable. The electronic analog computer can perform all of the usual arithmetic operations, and in addition, it can integrate with respect to time and generate nonlinear functions. The ability to integrate is perhaps its most useful characteristic. High order linear and nonlinear differential equations are readily solved. Partial differential equations with separable variables can sometimes be treated as eigenvalue problems and solved. Where the variables must be treated as continuous functions, one must use the technique of finite differences. This technique is readily applied to problems having only two independent variables where only one of these variables must be continuous. The problem to be described in this paper falls in this category.

THE PROBLEM

Figure 1 is a schematic representation of a Yankee drier system. The sheet is applied to the drier by means of a pressure roll at A. If the sheet is cooler than the drier surface, heat must be supplied by the drier to increase the sheet temperature. After the sheet reaches equilibrium temperature, it enters a period of constant drying rate. At some point on the drier circumference, B, the drying rate will start to fall, reaching a minimum at the doctor blade, C, where the sheet is removed. Between the doctor blade and pressure roll, the heat loss from the drier surface is very low since no drying is being done. The interior of the drier is maintained at constant temperature by means of steam. The problem is to determine the variation in temperature, in the machine direction, of the drier surface. The surface temperature will not be constant because of the varying heat flux through the drier surface required to satisfy the drying rate demand of

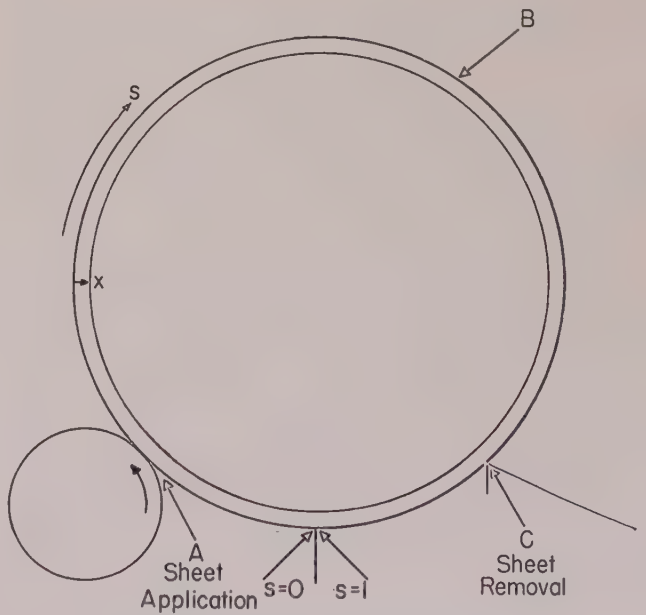

Fig. 1. Schematic diagram of a Yankee drier system

LOWELL W. ZABEL, Chief, Instrumentation Laboratory, Research and Development Div., Kimberly-Clark Corp., Neenah, Wis.

the sheet. From the point of view of paper machine operation, it is undesirable to apply the sheet to a surface that is too hot, as this can result in blistering and other operating difficulties.

Assume that all of the heat flow is radial. Then if we consider steady state conditions, the equation describing the temperature between two shells perpendicular to the direction of heat flow is:

$$\text{Input} - \text{Output} = \text{Accumulation} = 0 \qquad (1)$$

$$\text{Input} = kA\frac{dT}{dx} \qquad (2)$$

$$\text{Output} = kA\frac{dT}{dx} + \frac{d}{dx}\left(kA\frac{dT}{dx}\right)dx \text{ or} \qquad (3)$$

$$kA\frac{d^2Tdx}{dx^2} = 0 \qquad (4)$$

where

K = thermal conductivity
A = area for heat flow (perpendicular to the direction of heat flow)
T = temperature in °F.
x = distance through the drier shell in the direction of heat flow.

Since we are not operating under steady state conditions, the accumulation term is not zero. It becomes

$$\rho ACpdx\frac{dT}{ds} \qquad (5)$$

where

ρ = shell density
Cp = heat capacity
s = distance around the drier.

Combining equations (2), (3), and (5) in a partial differential equation we have:

$$\frac{\partial^2 T}{\partial x^2} = \frac{\rho Cp}{k}\frac{\partial T}{\partial s} \qquad (6)$$

This equation describes the unsteady state heat flow through the drier shell and is the equation that we desire to solve.

THE SOLUTION

Our primary interest is the variation of the temperature, T, with position, s, around the drier. Since the drier will be operated at constant angular velocity, s will be proportional to time. The finite difference method of solution with T and s continuous and x taken in discrete intervals was used. Since some of the primary data were not known with high precision, we used the second-order finite difference approximations rather than the more accurate and more complicated higher order substitution equations. The substitutions required are:

$$\left.\frac{\partial T}{\partial x}\right|_n = \frac{T(n+1) - T(n-1)}{2\Delta x} \qquad (7)$$

$$\left.\frac{\partial^2 T}{\partial x^2}\right|_n = \frac{T(n+1) - 2Tn + T(n-1)}{(\Delta x)^2} \qquad (8)$$

Making these substitutions into equation (6) and rearranging terms, we have:

$$\frac{dT_1}{ds} = \frac{1}{(\Delta x)^2 B}(T_2 - 2T_1 + T_0) \qquad (9)$$

$$\frac{dT_2}{ds} = \frac{1}{(\Delta x)^2 B}(T_3 - 2T_2 + T_1) \qquad (10)$$

$$\frac{dT_3}{ds} = \frac{1}{(\Delta x)^2 B}(T_4 - 2T_3 + T_2) \qquad (11)$$

$$\frac{dTn}{ds} = \frac{1}{(\Delta x)^2 B}(T(n+1) - 2Tn + T(n-1)) \qquad (12)$$

where

$$B = \frac{\rho Cp}{k}$$

T_0 = the temperature at an arbitrary shell within the drier shell

T_1 = the temperature at the shell Δx inches toward the cooler surface from T_0

Previous work on this problem indicated that, although the drier surface varied in temperature with varying drying loads, this variation did not extend very far into the drier shell. The temperature 1/4 in. or more from the outer surface remained essentially constant. Because the forcing function to be applied in the present work is more drastic than that used in the previous work, it is desirable to use a thickness greater than

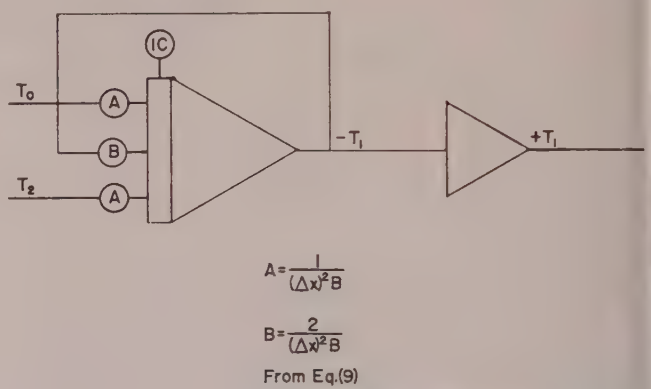

Fig. 2. Computer diagram for the solution of one elementary equation

1/4 in. To obtain greatest accuracy, it is desirable to use a small Δx. The size of Δx is limited by the amount of computing equipment available. A compromise was made on the basis of intuition. One half inch was selected as the shell thickness. The temperature 1/2 in. from the outer surface was considered to be a constant. This was designated as T_0. The 1/2 in. was divided into 25 equal segments, making Δx equal to 0.02 in. and n in equation (12) equal to 25. Thus there are 24 simultaneous first order differential equations to be solved. The inner boundary condition determines T_0 which is a constant. The outer temperature variation is to be determined. The second boundary condition that we can impose on the system is the temperature gradient at the surface of the drier. This, then, is our forcing function, $f(s)$, where $f(s) = T_{24} - T_{25}$. This function is calculated on the basis of the heat transfer, required to produce the known drying rates, expressed as the temperature gradient dT/dx, at the outside surface of the drier.

A single computing amplifier can simultaneously perform an algebraic addition, an integration, and sign change. The computer solution to equation (9) can be obtained with computer components arranged as shown in Fig. 2. This set up will solve the first of the simultaneous equations provided we have T_0 and T_2 available. T_0 is assumed to be constant. T_2 can be obtained from the solution of equation (10).

This procedure of obtaining T_{n-1}, T_n, and T_{n+1} from the solutions of equations describing the temperature of three adjacent shells is continued until the equation involving T_{24} and T_{25} is reached. This requires 24 interconnected systems identical to that shown in Fig. 2. The 25th equation, $T_{25} = T_{24} - f(s)$ can be solved by a simple summing amplifier. Figure 3 is a schematic diagram showing the interconnection of several of the systems of Fig. 2 and the summing amplifier required for the solution of the gradient equation.

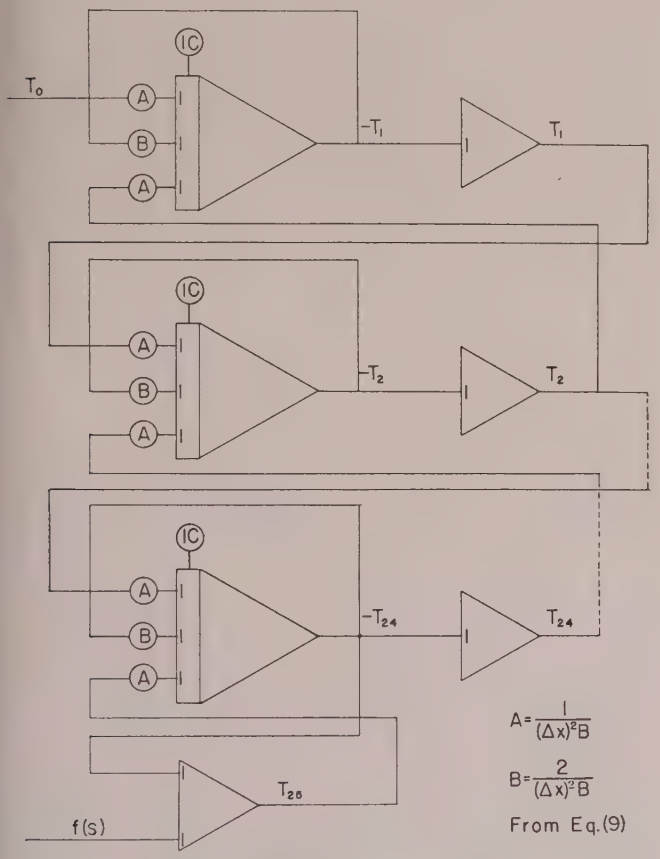

Fig. 3. Computer diagram for the solution of the simultaneous equations

The initial conditions to be imposed on the integrators may be arbitrarily selected since the system will eventually come to equilibrium. It is prudent to select a set of initial conditions close to the expected final values, as this will minimize the computation time. The conditions used approximate the average temperature gradient that would be experienced under steady-state conditions. The final element required to obtain a solution is a forcing function, $f(s)$. This is $\Delta T/\Delta x$ as a function of s. This function is generated by a special function generator constructed for the purpose. The generator consists of a synchronous motor driving a series of cams which in turn operate microswitches. On the same shaft with the cams is mounted a 360° rotation linear potentiometer, which is used to synchronize the recorder pen position with the function generator. The shapes of the function generated are shown in Fig. 4. The spike at the left of curve A represents the temperature gradient at the point of application of a room temperature sheet to the drier. This is followed by an exponential decrease in the gradient as the sheet temperature increases. When the sheet reaches equilibrium, it enters a period of constant rate drying, during which the gradient is constant. This period is followed by a falling rate period.

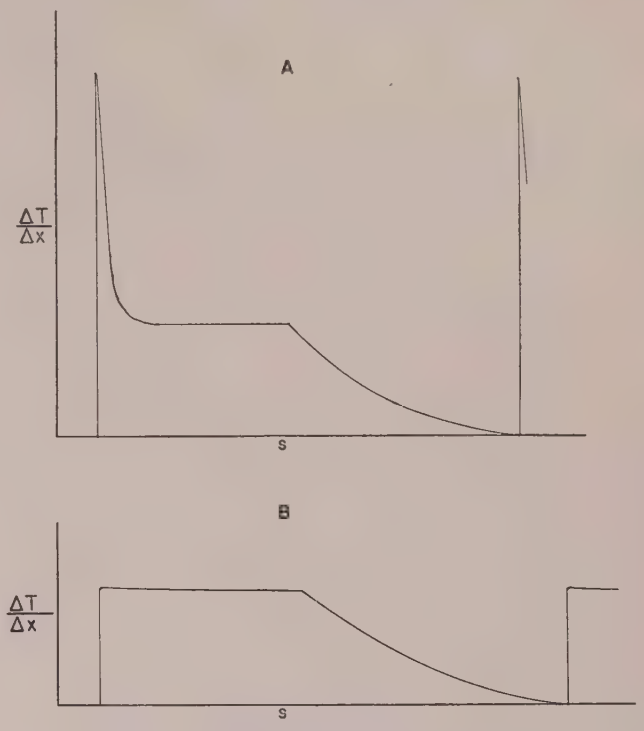

Fig. 4. Shapes of the forcing functions

A Cold sheet application. B Hot sheet application.

The exact shape of this portion is not known, but is assumed to be an exponential. The exponential holds until the sheet is creped off the drier, at which time the gradient again becomes constant, but at a very low value. The lower curve, B, in Fig. 4 indicates the shape of the s vs. $\Delta T/\Delta x$ curve for the application of a sheet whose initial temperature is the equilibrium temperature at the start of the constant drying rate period. The only difference between the two curves is the presence of the initial spike and exponential drop at the beginning of curve A.

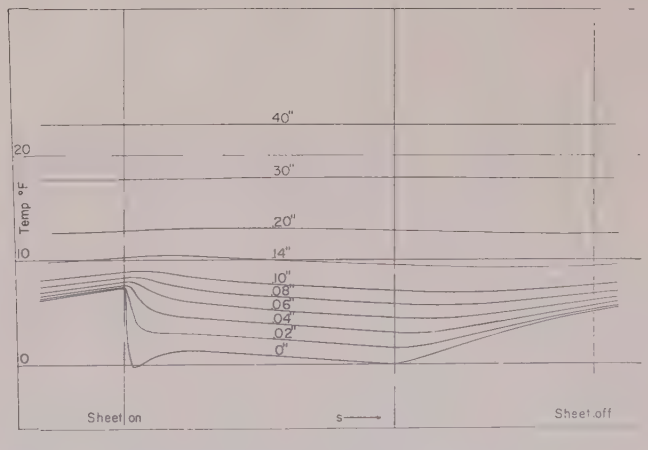

Fig. 5. Temperature distribution of a cast iron drier with hot sheet application

The temperature conditions for two driers were studied. One was a bronze drier having a high thermal conductivity and the other a conventional cast iron

drier. The shift between the two driers required only readjustment of the coefficient potentiometers feeding the various amplifiers. The problem was set up on an Electronic Associates computer. Trial runs were disappointing in that the results were quite inconsistent, but the difficulty soon became apparent. The level of the outer boundary temperature is a function of each integrator input setting. Thus, small potentiometer errors could be integrated into large temperature errors. Very careful setting of the coefficient potentiometers reduced these cumulative errors to tolerable levels.

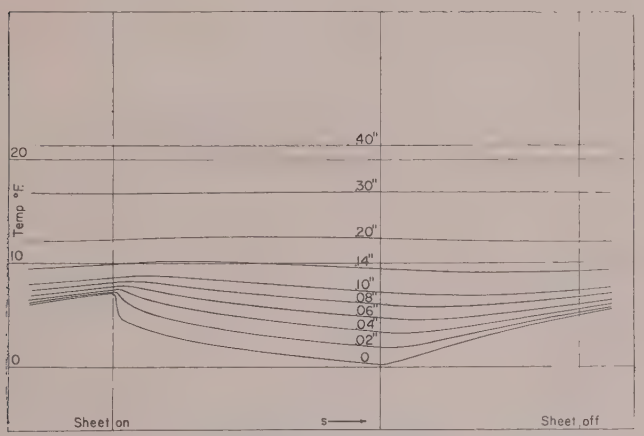

Fig. 6. Temperature distribution of a bronze drier with hot sheet application

Fifteen runs were made covering a range of machine speeds, basis weights, and the two drier materials. The results of four of the runs are shown in Figs. 5 through 8. Figure 5 shows the temperature profiles on a bronze drier running at 3150 f.p.m. with a 7.6-lb. basis weight sheet. The lower curve indicates the

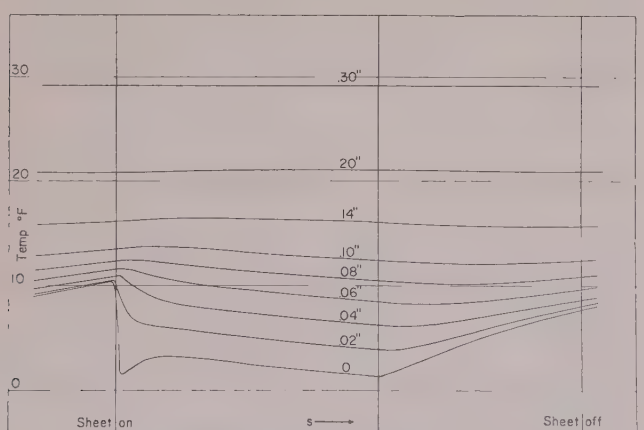

Fig. 7. Temperature distribution of a cast iron drier with cold sheet application

temperature variation at the drier surface. Each successive curve is the temperature distribution at the indicated distance radially inward from the outer surface. Starting at the left you will note a gradual rise in surface temperature. During this period the sheet is off the drier. At the time of application of the room temperature sheet, the surface temperature drops suddenly. As the sheet approaches the temperature of the drier surface, the surface temperature increases slightly and then falls gradually during the constant drying rate period. During the following falling drying rate period the temperature gradually rises with almost no demarcation at the point of sheet removal until the sheet is again applied. Note that the effect of the variable heat flux due to the presence of the sheet is almost zero at a distance of only 0.14 in. from the surface. Note also that each successive profile is displaced to the right. This is expected because the combination of thermal resistance and thermal capacity results in a time delay.

Figure 6 is identical to Fig. 5 except that the sheet is applied to the drier at the equilibrium temperature. Note the complete absence of the initial spike at the point of sheet application. Also, the average difference between T_0 and T_{25} is greater in the case of Fig. 5 than in the case of Fig. 6 because of the greater average heat flux required for initial heating of the sheet.

Figures 7 and 8 are repeats of Figs. 5 and 6 except that the drier material was cast iron. Due to the lower thermal conductivity of iron, the speed was

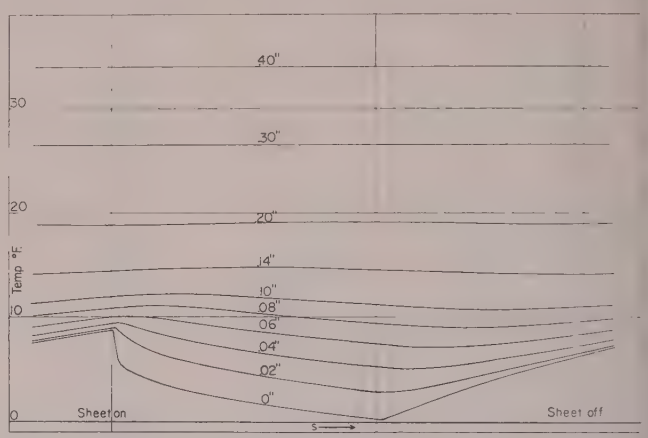

Fig. 8. Temperature distribution of a bronze drier with cold sheet application

reduced to 2200 f.p.m. These curves have the same general shape as those for bronze, but show differences in the magnitudes of the temperature gradients and the temperature variations during the drying cycle.

Once the problem had been defined and the initial, boundary, and forcing function specified, approximately 4 man-days were required to convert the original equations to computer equations, program the computer, and prepare a detailed plan of action for the individual runs. Eight hours were required to wire and check out the computer and to make the 15 runs. The accuracy, although not as high as obtainable by digital methods, was adequate. The speed of operation and ease with which a wide variety of conditions could be investigated made the analog approach attractive.

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Improvement of Hardwoods Through Genetics

PHILIP N. JORANSON

Some attention is given to genetic improvement of hardwood growth rate, but discussion focuses primarily upon the conditioning effect which differences between the genetic constitutions of trees may have upon those properties of wood developing within the tree, which are of particular importance to the pulp, paper, and paperboard industry. Three general areas of industrial interest which may be affected by pulpwood quality differences are recognized. As a concrete example chosen from one of these areas, the nature and possible justification of a genetic approach to sheet strength improvement are explored in some detail, and with reference to recent fundamental studies of pulp influence upon sheet strength.

No SPECIES of plant or animal, properly speaking, is composed of a single, fixed genetic make-up. In fact, botanists, foresters, and geneticists all agree that a species, designated by a Latin term such as *Populus tremuloides* (quaking aspen), is an astronomically large number of somewhat varying individual trees, extending widely in space and deeply in time, which resemble each other sufficiently so that they would not ordinarily be mistaken for individuals belonging to a different space-time group such as *Populus grandidentata* (bigtooth aspen) or *Populus alba* (white or silver poplar).

We are now certain that some of the easily observed differences between *P. tremuloides* trees, even within a single forest stand, are the direct outcome of the fact that they are distinguished internally by differences in the detail of a highly intricate mechanism of predisposition which is deeply seated within each of them and which, to a large extent, guides their development. Thus, trees in an even-aged forest stand do not differ from each other in the volume or quality of wood produced, *only* because they have unequal opportunities in the soil and above ground, but *also* because each tree is guided in its total development by a more or less unique setting of an inner predisposing guidance mechanism, i.e., by its heredity. The master-minding of successive stages in development which is accomplished by each individual tree's heredity is not unlike the program of successive operations which one feeds into an automatic computer to accomplish a complex operation, but the total programming which is written into the heredity mechanism which guides the development of a single tree is far more complex than any that has ever been fed into an automatic computer.

The genetic mechanism which guides the growth of a tree is "adjustable" for dozens of characteristics relating, for instance, to the volume of wood produced; its physical, chemical, and anatomical properties; and the individual's resistance to a specific tree disease. Each individual tree seedling which survives in nature has a "personalized" genetic program for development which it owes mostly to an essentially random reshuffling of the elements of hereditary predisposition—the genes—at the time of sexual reproduction. For some individuals, the outcome of encounter with the local environment in which development initiates, is not life, but death, as the inevitable result of a less than adequate genetic programming; for others it is survival, with the genes then cooperatively spelling out the individual's developmental tendencies, and the environmental factors in greater or lesser degree modifying the genic expression.

So the genetic component of "natural variation" (differences between individual trees as they occur in nature) must loom large in the evolution of a tree species, since only the individuals whose particular genetic make-ups will permit their continuance will be able to reproduce and so transmit their advantage to yet other generations of offspring to come. If among the individuals of a species there is a considerable range of variety in the genes which relate to survival, then the species will tend to include some individuals whose specific genetic make-ups are capable of meeting the conditions of a changed environment. These individuals are the species' insurance against extinction when environment changes, as it always does sooner or later during evolution. There is not necessarily safety in numbers, but there is safety in genetic variety of the right sort.

But if genetic variety in the natural population of a tree species is essential for continuance of the species, it is not of less importance in the work of the forest geneticist. If there is little genetic difference between individuals, regarding the characteristics which he hopes to improve, or if he cannot by various breeding techniques induce the gene differences he needs, then his efforts will be futile. This is the first need then, in a genetic approach: to be able to find, or in some cases to produce, genetic differences which are great enough to have real bearing upon the characteristic which is to be improved. This is not *all* he needs to have, for other information—some from fundamental studies in pulping and papermaking, and some yielded up by applying further the geneticist's own analytical methods—must also be brought to bear, as will be noted later, but this much is a first and a very characteristic essential.

Resources and Focus of the Present Discussion

While it is true, as has been suggested, that many characteristics of species used for pulpwood might prove alterable through genetic manipulation, the following discussion will relate very largely to genetic improvement of those wood properties which are of particular consequence to the pulp, paper, and paperboard industry. Some attention, however, is also given to growth rate improvement.

One does not need to go very far in a genetic program to improve a wood property before discovering that it is many-sided and full of interrelations. Some device is needed to focus and interrelate in research the

PHILIP N. JORANSON, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

several contributions of those who have essential special knowledge. Else the truly relevant thinking which must lead the experimental attack is put off too long, and in the meantime one may easily fly quite unaware over important targets.

For several years, a group representing a number of specialized research areas at The Institute of Paper Chemistry has been engaged in a precise analysis of pulp properties which most influence sheet strength. The principal findings in these studies, which are described in detail in three papers soon to appear in *Tappi*, form the groundwork for a discussion of genetic approach to sheet strength improvement which is included in this paper. With the help of Malcolm N. May, Nicholas A. Jappe, and William L. Ingmanson—all of whom participated in the strength investigation—a condensed statement of factors and behaviors revealed in that study has been incorporated as a foundation for the sheet strength improvement discussion.

The Institute's program for genetic study and improvement of aspen emphasizes pulpwood properties, and as much as possible takes advantage of opportunities, through close ties with various departments, to discern improvement objectives more clearly. In this running partnership, Dean W. Einspahr, J. P. van Buijtenen, and the writer have represented the participation of genetics, and many of the observations which follow reflect a developing perspective to which each has made substantial contribution.

To Carlos M. Flinta of the United Nations Food and Agriculture Organization's Forestry Division, we are grateful for opportunity to include personal observations of programs in various parts of the world where advantage is taken of the exceptionally rapid growth of species of *Populus*, *Salix*, and *Eucalyptus*.

The Physical and Chemical Basis of Genetic Improvement

Pulpwood in the hands of a papermaker is a mass of useful fibers cemented together which he may isolate from each other, further modify in various ways, and form into a sheet of paper of certain specifications. The success of this operation depends strongly upon the effectiveness of a series of processing modifications which are imposed upon the fiber before it becomes bonded in its final position in a sheet.

But every fiber in the wood, as it is received from the forest, is *already* the net result of an earlier series of influences affecting its shape and structure, and its physical and chemical nature. These influences are rather sharply classifiable into two groups of factors which are engaged in simultaneous play upon the characteristics of the growing tree, as for example, upon the amount of a given chemical constituent in the fiber wall or, in terms of the tree at large, the rate of growth in height, or the degree of resistance to a disease. Of these two groups of influences, one is *external*, or environmental, to the effect which it produces. It includes such factors as temperature, day length, and soil moisture and, collectively, is referred to as "environment." Some of its factors are subject to a degree of desirable human control in forest management.

The other group of influences is *internal* and can be traced to a very definite physical mechanism which operates in every living cell. This functioning of an inner master control in the living material we have called heredity. It is when we are able, with advantage to exercise a degree of intelligent control over the consequences of heredity that we are in a position to apply a genetic approach to pulpwood improvement.

The functioning of heredity is in two different directions, one addressed to the living being which houses it, and the other concerning its remarkable ability to perpetuate itself into succeeding generations. So we see heredity on the one hand as a propensity to spell out in individual terms the detail of life processes, structures, and compositions, and on the other, in terms of its capacity to arrange for transmission of its own substance to the next generation, at the same time that this substance is rearranged in novel ways. Reproduction according to such a method yields many genetically different individuals which are able to repeat the whole intricate trick all over again.

How is it, then, that hereditary and environmental influences can work together? Environment provides the raw materials and the total context with which, and within which, heredity works. Thus environment both makes heredity's role possible and in varying degrees, depending upon the attribute involved, shapes the end result of specific, but somewhat plastic, hereditary influences.

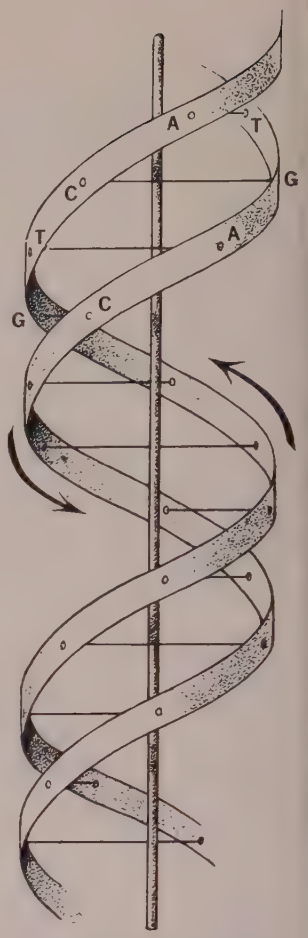

Fig. 1. Proposed chemical model of the chromosome. In this extremely short chromosome section, the two helices represent desoxyribonucleic acid chains; appearing as cross links, are sequences of amino acids (A, C, T, G—see text) always the same four, but in varying sequence. From Watson and Crick (1), after Sinnott, Dunn, and Dobzhansky (2)

Being a bit more definite now, we will trace these "hereditary influences" to the individual genetic units called "genes," which we identified earlier. The evidence has been accumulating for a long time that each gene has a significant effect upon the development of at least one plant characteristic and, though they are not visible as such, that the genes are strung out linearly in elongated bodies called chromosomes, which are distinguishable at the higher magnifications of the light microscope.

Recently, mounting attack on several fronts upon the chemical structure of the chromosome has broken through to provide at least a reasonable chemical model of the chromosome, which as biology's basic structure, is comparable to the model of the atom as the basic unit of chemistry.

As shown in Fig. 1, the chemical structure, revealed

by a chain of evidence from microanalysis, x-ray spectrography, and electron microscope studies, indicates that a chromosome is a very long double helix whose two spiralling members are built of desoxyribonucleic acid.

Regularly spaced cross links—each consisting of a purine unit linked through a hydrogen bond to a pyrimidine—extend between the two helices. The kind of purine and of pyrimidine unit in successive links is variable. There are only two kinds of purine—adenine and guanine (A and G in Fig. 1)—and two kinds of pyrimidine—tyrosine and cytosine (T and C in Fig. 1). These apparently may occur in many different link-to-link sequences of purine bonded to pyrimidine, with a single gene possibly often extending through a number of cross links. Such an hypothesis is quite in line with estimates made on other grounds that a complete set of chromosomes may contain at least several thousands of genes.

The genes borne on an entire complement of chromosomes, whether of a tree or a fish or a man, carry the total information necessary to develop the complete detail of the fully formed individual. It has been estimated that, to write out all of the instructions needed to make a fully developed human being which are actually coded on the chromosomes in the single cell from which he gets his start, would require space available in 50 complete sets of a 20-volume encyclopedia!

Before leaving the chromosomes, we should note that most trees contain two complete sets of chromosomes (in aspen $=2\times19$) in their cells, one set being derived from the maternal, and the other from the paternal parent. This double number of sets which would be found in all of the cells of most trees, is called "diploid." A "polyploid" number of chromosomes (three or more complete sets) may be found sometimes in species of not a few hardwood genera.

Opportunities for Industrial Application of Genetic Information

The degree of genetic control over a pulpwood property which is sought tends to determine both the type and extent of the minimum foundational genetic information about the species which must be secured. One kind of basic genetic information may sometimes justify attention at a very early stage because of its potential economic bearing on policies of pulpwood procurement and forest land acquisition, and upon forest management plans. It is known, for instance, that geography and climate may have had some significant differential effects upon the genetic make-up of the species during its evolutionary spread. When the evidence of the past is pieced together, it often indicates that a species first appears in a limited area and then gradually radiates out from it to cover a much larger range. The migration of a species away from the center of origin brings it into contact with new environmental conditions, and these become a challenge to its ability to survive. Such pressures of an ever exacting environment tend to eliminate some of the previously successful, but now inadequate, genetic make-ups, to favor better adjusted types, and so to give rise to certain changes in the average genetic make-up and consequent characteristics of the species as it spreads into new regions.

If the direction of spread should happen to correspond with gradual change in a climatic factor such as rainfall or temperature, or in day length, it might be reasonable to expect a reflection of this fact in the way in which the species manifests certain characteristics, such as fiber length, wood specific gravity, or time when terminal growth ceases. As a matter of fact, there is evidence that gradients of these three types may exist, in certain tree species. When the variation of a characteristic follows such a trend it is called a "cline." If marked clinal variation has been thoroughly established with respect to a significant pulpwood property, such genetic information may sometimes have useful application in the forest.

Another possible locus for profitable application of genetic information may be in "seed production areas," i.e., exceptional wild stands composed of trees which are outstanding in volume growth and/or form, and are to be managed and used for seed collection. Even in a seed production area, therefore, it may become desirable, if a rapid, inexpensive method for evaluation can be applied, to enhance quality in the generation which follows by cutting out trees whose wood sample cores reveal unfavorable test values for the wood property of interest.

The next most intensive method, which is presently in use with pines and spruces, is to arrange for seed production in so-called "seed orchards" in which scions from superior selected trees are concentrated, ordinarily by grafting onto seedlings. Seeds produced in seed production areas and in seed orchards are sown in the nursery to provide planting stock.

First generation (F_1) hybrids of aspen and of cottonwoods and black poplars are planted on a commercial scale today, in special circumstances, and first generation triploids of aspen, as produced and described by Johnsson (*3, 4*), and apparently of some other hardwoods, have also shown promise. If it seems desirable to exploit genetic potentials even more fully, then the program may include some of the more intensive methods which are in common use in genetic improvement of agricultural crops, but here it is well to note that before a new variety of even an annual crop can be proved out for release, some 15 years, at least, will have elapsed. In forest tree improvement, the future raw material requirement may often be too unpredictable as regards both the kind of process which may be used, and the kind of product which is likely to be manufactured, to justify as intensive an approach to genetic improvement of a wood property as is called for in improvement of annual agricultural crops.

In the case of a characteristic such as growth rate, genetic information can be applied sometimes directly by modifying current cultural forest practice in order to favor reproduction from those trees which have the better genetic make-ups. A genetic application of this kind is not favorable for the improvement of a wood quality characteristic, however, unless it becomes possible to diagnose the wood characteristic, in terms of a correlated, exteriorly observable tree characteristic.

An interesting field demonstration was arranged recently by Schreiner (*5*) to demonstrate how genetic principles relative to increment and tree form might be applied in silvicultural practice. This became a live subject earlier in Europe than in America, and has been discussed at length by Stefansson (*6*).

STATUS AND PROSPECT

Recent Progress in Forest Genetics and Tree Improvement, as a Whole

During the past ten years, and at a markedly rapid rate during the past several years, forest genetics and forest tree improvement have shown much growth. Early programs initiated 25 or more years ago in Sweden, France, Germany, The Netherlands, Italy, Australia, and the United States tended to stimulate interest in other places. Countries now active are three times as numerous, represent all of the continents, a variety of emphases in objective and various stages of program development.

A brief glance at principal phases of forest genetics and tree improvement as they have developed in the United States and in some areas of international cooperation will show how considerable a momentum has resulted. Basic studies needed to clarify and facilitate approach regarding such phenomena as wood property gradients within the tree, have increased in number; a variety of improvement goals is being undertaken, among which attention to wood quality and the relation of experimental trees to climate, soil, diseases, and insects are much more prominent than formerly; the critical and immensely broad area of methods research is being recognized and advanced; associated and much needed inquiries in fields such as the physiology of rooting and flowering, forest tree nutrition, and basic behaviors underlying papermaking have been accelerated; new vehicles for scientific and other liaison (*7–10*) have been provided which link geneticists locally, regionally, and nationally with other scientists, with practicing foresters, and with pulp and paper company personnel in woodlands, manufacture, and administration; nearly all of the world's pulp and paper institutes are aware that the genes have found their way into papermaking; publication (*11*), bibliography (*12, 13*), and abstracting (*14, 15*) are being handled in thorough fashion, with perhaps only the translation of vital foreign language articles seriously lagging; undergraduate, graduate, and short or special course education have all expanded; and the terminology of forest genetics and forest tree improvement has received much attention by the Forest Tree Improvement Committee of the Society of American Foresters (*16*).

Two serious handicaps which have restrained progress in the past have recently yielded somewhat to experimental attack. They concern the frequent need to wait many years before (1) the first appearance of flowers, whose specialized structures are indispensable for producing a new experimental generation from seed, and also (2) before trees become mature enough to be characterized with assurance as regards growth rate, wood properties, etc. At least for some species, there is now real hope of overcoming both difficulties to some extent at least, and sometimes very substantially. If forest geneticists choose to be vigorous in the search for time-sparing, cost-saving juvenile characteristics which can be used in making predictions of some reliability about tree and wood characteristics to be expected at maturity, they may be in a position, not often occupied, to make contributions from forest genetics into the general fund of genetical knowledge upon which other geneticists, such as those working with fruit trees, coffee, and rubber, will welcome. The general genetics journal *Der Züchter* devoted an entire issue this year to the need in many breeding fields to find early indications of the genetic superiority of individual plants and animals.

New as well as existing programs for hardwood improvement are the fortunate heirs of a valuable fund of general knowledge which carries over into their programs from the vigorous earlier work in the conifers, especially the pines and spruces. Among specific literature resources of timely value will be a selected and annotated bibliography devoted to effects both of environmental factors and of genetic variation upon wood characteristics which are of significance in papermaking. Initiated this year under the leadership of Philip R. Larson of the U. S. Forest Service Northern Institute of Genetics at Rhinelander, Wis., this project was undertaken as a project of a Subcommittee of the TAPPI Forest Biology Committee.

Genetic Improvement of Hardwood Species—Status and Prospect

The Genus Populus L.—*"Poplars."* There has been no slackening of effort in the genus *Populus* L., which continues to receive more study worldwide than any other hardwood genus. Selections within species and of spontaneous hybrids which have arisen in the field, as well as hybrids produced artificially, are employed in commercial scale plantations, especially in Europe and South America.

Among the species represented are the white poplars and aspens (Section *Leuce* Duby), balsam poplars (Section *Tacamahaca* Spach.), and the cottonwoods and black poplars (Section *Aegeiros* Duby). Pauley (*17*) has prepared on exceptionally detailed and usefully critical review of many phases of *Populus* improvement, not the least valuable of which is a section on the need to be wary of nomenclatural uncertainties in research upon the hybrids. The International Poplar Commission, holding conferences every 4 years and organized within the Forestry Division of FAO, facilitates worldwide cooperation in poplar research and culture.

So much work with *Populus* species has been reported that it is impossible to do more here than cite selected papers which deal with various aspects of genetic improvement, and to indicate specially relevant results later, in a discussion of selected topics. Two collections of papers—one edited by Hesmer (*18*), which includes a valuable essay by Jayme (*19*) on "Poplarwood as Fibrous Raw Material," and the other in the form of a special issue of *Holzforschung* for February, 1958—provide much information and show how many-sided is the interest in cottonwoods, black poplars, and aspens. The orientation offered by these two collections may be extended in various directions by reference to Heimburger (*20*); Johnsson (*3, 4*); Marcet (*21*); Peace (*22*); Schreiner (*23*); Stout and Schreiner (*24*); van Buijtenen, Joranson, and Einspahr (*25*); and Wettstein (*26*).

Other Hardwood Genera. The successful planting (*27*), and rapid growth of a number of *Eucalyptus* species in a wide area between Australia and southern

Europe, in Africa, and on the American continents, coupled with a growing research interest in *Eucalyptus* species in their native area of Australia and environs, has put this genus very much to the forefront. The fact that ten or more different *Eucalyptus* species are pulped together in an ordinary day's run at one Australian pulp mill suggests the richness of genetic variability available to the breeder; it also suggests that possibly that mill's quality control department stocks, among other things, a large supply of aspirin! Pryor, Chattaway, and Kloot (*28*) have recently reported evidence of important variation in wood quality of *Eucalyptus* among its hybrids.

Hardwoods which have come into prominent use in pulping, as species indigenous and locally available to pulp mills, include the birches (*Betula*), maples (*Acer*), oaks (*Quercus*), willows (*Salix*), beeches (*Carpinus*), southern gums (*Nyssa* and *Liquidambar*), sweet bay (*Persea*), alders (*Alnus*), and yellow poplar (*Liriodendron tulipifera* L.). No attempt will be made here to review completely the literature regarding information which would help to orient tree improvement programs addressed to these species, but some useful works will be cited.

Planting of gum, which is now extensively pulped in the southern United States, has been undertaken, and willows are grown from cuttings in bottomlands in Argentina. There seems to be no convincing reason for delaying studies of natural variation and investigating improvement by selection in sweet gum (*Liquidambar styraciflua* L.). It is a well formed, rapidly growing, widely distributed species which occurs on a variety of sites.

Gabriel's (*29*) recent summary of activities gives convenient access to the names of institutions and agencies in the northeastern section of the United States whose programs include hardwoods; information on a variety of mostly northern hardwoods is given in the *Proceedings of the Annual Northeastern Forest Tree Improvement Conferences*, beginning in 1954 (*30*); and Richens' (*31*) comprehensive review of literature appearing before 1945 is a valuable compendium which includes a number of hardwood genera. The genetic improvement of oaks (*Quercus*) was recently surveyed by Irgens-Moller (*32*) and Behrndt (*33*) has surveyed possibilities in birch improvement.

For most species, there is scanty information regarding the extent to which individuals in the forest differ from each other for genetic reasons. Only when such differences are substantial with respect to the characters of interest will selection of outstanding individuals hold promise as an effective improvement method. Distinct races or subspecies of some of the hardwood species, for example, *Carpinus*, *Betula*, and *Acer*, have been recognized [see Wright (*34*)], and artificial crosses between individuals representing different species of a tree genus are often not difficult to effect. Polyploid incidence has been reported in most of the hardwood genera and ranges from single individuals of natural or artificial origin, to races and species.

For most of the hardwood species which are of interest, very little is now known on the basis of which a tree improvement program could be justified, but judiciously directed exploratory work is certainly in order. Attention will be given in sections which follow, to factors which influence both the possibility and the over-all justification of genetic approach to the improvement of specific wood properties.

GENETIC IMPROVEMENT OF HARDWOOD GROWTH RATE

Genetic improvement of a forest tree species most often begins with attention to the efficiency of production of usable wood per unit of land area. It is usually some time, however, before this evaluation can be made, since it requires comparative field testing with statistical controls for at least one tree generation and on at least several different, suitable, and reasonably well-described sites, to measure performance. Even then there may be climatic, disease, insect, or various other threats which have yet to be asserted. Damage from these sources tends to be minimized when the improved trees come from fairly local origins, and to increase when divergent heredities are brought together by producing hybrids, although neither of these rules should be regarded as implying a prohibition.

In the crop trees which make up the harvest at the end of the rotation, not only diameter inside bark and tree height to the permissible top diameter, but also straightness, degree of taper, and branch characteristics become factors affecting total usable volume produced in the stem. Specific gravity and other properties of the wood itself—to be considered later—may influence the yield of pulp from the usable wood produced.

It ought to be evident, but often is not, that where eventual use in forest plantings is anticipated, observations based upon the first few years of growth of but a single row of trees on an unusually fertile, moist, well-drained loam may be quite misleading, if in later commercial practice one would expect to grow them longer before cutting, to space them more closely, and never to have opportunity to plant them on soils of such superior quality.

Some hardwood species such as cottonwood, aspen, some species of *Eucalyptus*, several of the southern United States gums, and western alder have such a high inherent rate of volume increment on sites to which they are well adapted, that the choice of the species with which to work sometimes may be one of the most significant judgments which the geneticist makes.

Selecting outstanding trees in the forest, introducing a related species, producing hybrids between species, and finding or producing polyploid forms all have shown promise as methods which may be useful in increasing annual wood increment, in one hardwood pulping species or another.

It is often not clear, even in the case of poplars, whether the greatest increment improvement may be obtained from selection or by making crosses within or between species. The improvement methods mentioned are by no means entirely independent of each other with respect to the genetic basis for the efficacy of each. In general, a great deal depends upon the amplitude of variation between individual trees in nature, and here not nearly enough information has been secured.

With very few exceptions, little is yet known from actual plantings about genetic opportunity to increase

per acre wood production in the hardwood species which have come into use for pulping. *Eucalyptus*, poplar species and hybrids, and willow species and hybrids are exceptions. Flinta (*35*) has reported that under favorable conditions in the vicinity of Buenos Aires, Argentina, plantations of *Eucalyptus* species varying in age from 6 to 44 years have grown at annual rates of 20 to 45 cu. m. per hectare (286 to 643 cu. ft. per acre, or 2.2 to 5.0 cords per acre). Culture of poplar hybrids and of willow in the delta of the Paraná River of Argentina also produced exceptional yields of wood. In the Unites States, the growth of cottonwood on Mississippi River bottomlands and benches has attracted much attention.

GENETIC IMPROVEMENT OF THE WOOD AND FIBER PROPERTIES OF HARDWOOD SPECIES

Evaluation of Factors Which Influence the Possibility, and the Over-all Justification of a Genetic Approach to Improvement

Here again it is necessary to maintain as clearly as possible a distinction between the kind and degree of improvement which appears to be attainable through genetic means, and the over-all justification for pursuing a genetic approach. When the aim is to improve wood quality, relations between estimates of possibility and estimations of practicality may be quite involved. It makes some difference, for instance, whether one wishes to modify wood quality only to secure higher pulp yield, or also to enhance paper strength or other essential sheet property.

Also, if it is proposed to improve a sheet property, or to reduce processing cost, through genetic modification of wood properties, it will be necessary to give a sound reply to him who asks whether it would not be technically more promising, quicker, and cheaper to attend instead to possible improvements in processing procedure. In many cases, however, we probably know too little about the conditions which govern the chance for success by either approach to say flatly that this is an "either-or" proposition.

During the past year or two at The Institute of Paper Chemistry, some opportunity for parallel pursuit of both approaches has tended to make it appear more as a "both-and" prospect, not only in an additive way, with respect to results, but also procedurally, in terms of liaison in research. The linkage sometimes has come to involve, not only exchange of information, but also joint planning and joint study of the same pulpwood samples. For not long after his work is under way, the geneticist comes into possession of wood samples from a number of individual trees which provide strong contrasts in wood properties and are therefore of particular value, both experimentally and developmentally, in the running partnership between pulp and paper scientist and geneticist.

To return to estimations of possible improvement though genetic attack, it is very clear that if a positive judgment is reached, it must rest on reasonably satisfactory answers to each of four general questions, as follows:

1. Can a measurable wood property of sufficiently clear bearing upon the sheet property or processing cost factor which is to be improved, be reported out of pertinent basic studies of such a relation?
2. Regarding this wood property, (a) how widely in nature do individual trees differ from each other, or—usually as a secondary question—(b) how widely could trees be made to differ from each other because of changes in genetic make-up achievable through hybridization, discovery or production of polyploids, or induced mutation?
3. What are the chances that the offspring of trees secured by any of these methods will display the wood property advantage which was observed in their parents, at a similar level?
4. How good are the chances for successful commercial scale growth of the qualitatively superior trees, i.e., in terms of cost of reproduction and establishment, adaptability to site and competition, and resistance to damage by diseases, insects, and climatic extremes?

There is no avoiding of any of these questions in the design of the tree improvement program. The first question arises out of industrial requirement, but the remaining three are all consequences of the formidable fact that our raw material is produced by living things—living things whose useful substance does not come to us except in terms of exacting conditions imposed upon them and also upon us, in our dual role of husbandman and beneficiary.

Areas of Interest

Yield of Pulp. In hardwood pulping species, summerwood is generally of much less significance than in the case of the hard pines, as a variable which contributes to wood specific gravity and pulp yield. There are good indications, nevertheless, that wood specific gravity in some hardwood species shows important variation from tree to tree, and between hybrids involving different species combinations. Jayme (*19*), for instance, reports that the specific gravity of native *Populus* species in Germany varies from 0.33 to 0.46, mostly between 0.40 and 0.44, whereas among hybrids under test, an exceptional value of 0.57 was found for the Schreiner and Stout hybrid clone "Oxford," and at an age of only 3 years.

In addition to specific gravity there are other wood factors which seem to offer some possibility as handles for genetic efforts to improve pulp yield. These include per cent holocellulose, or specifically of alpha-cellulose (in producing dissolving pulp for synthetic fibers), wood factors which affect the facility of removal of lignin, the content of extractives (and of pentosans, in the case of dissolving pulp) which resist removal during pulping, and the percentage of knot wood and of tension wood, the latter condition being associated with high cellulose content. Schönbach (*36*) has reported a method by means of which it has been possible from small samples taken outward from the fourth ring, to identify high cellulose trees of the species *Populus berolinensis*, and also among the offspring of this species crossed with the North American species *Populus trichocarpa*.

Contrary to widespread belief, lower specific gravity does not necessarily result from rapid growth. In passing from wood property influence upon pulp yield, to consider wood influence in two other areas of industrial interest, it will be noted that the same pulp property may affect characteristics in more than one of the interest areas.

Processing Cost. Although the cost of pulpwood outweighs the sum of costs incurred in processing it, yet the outlay for major items of processing cost is too considerable to be overlooked as an interest area

which is possibly subject to important genetic influence upon pulpwood properties. Thus, in pulping, beating, bleaching, and papermaking, wood properties may affect the total cost of processing through their influence upon costs of power, chemicals consumed, and time required for cooking, beating, bleaching, and running on the paper machine.

No attempt will be made here to explore specific relations between these items and wood properties. Studies such as those of J. E. Stone and H. V. Green, to be reported later in this symposium, which deal in part with wood variability in resistance to the penetration of cooking liquor, suggest possible genetic approaches to the enhancement of penetrability (see page 700, this issue).

Under this heading also, it should be pointed out that through genetic modification it is undoubtedly possible to produce a raw material which is less variable in quality than the pulpwood supply which we have been in the habit of accepting from nature, just as she gives it to us. While more uniform raw material would be a real boon in pulp and paper manufacture, its achievement would, however, not be a simple matter, nor would a given type of qualitative uniformity be equally valuable to all pulpmakers and users. This is one of the kinds of considerations which show how important it is to recognize all along that trees which grow to maturity from the improved seedlings which we plant now are not likely to be pulped by exactly the processes which are current today, and that it is not guaranteed that all of them will be used for pulp.

Significant Sheet Properties. A third and well-recognized way, generally speaking, in which wood quality asserts itself in papermaking is through its influence upon sheet properties. We think, for instance, of such attributes of the wood as fiber length, fiber flexibility, and the presence of substances tenaciously held, which may color the sheet.

Pulp and wood contributions to sheet strength have received particular attention at The Institute of Paper Chemistry recently by investigators representing a variety of fields, including genetics. A fairly detailed account of this cooperative experience appears in the next section of this paper, in lieu of attempting a one-by-one discussion here of sheet properties which appear to be susceptible of influence through possible genetic control over particular wood properties. One advantage of proceeding in this way is the opportunity which it affords to confront concretely the various issues which are likely to arise. Somewhat similar general issues would be raised if similar detailed attention were given to the enhancement of other sheet properties.

Before considering sheet strength improvement, however, let us suggest several additional sheet properties, which to an important degree depend upon pulpwood characteristics. Such a list would certainly include, for instance, brightness, formation, printability, and relative purity of dissolving pulp.

At this point—lest it appear that the author is about to advocate a 10-million dollar crash program designed to create, before January 1, a self-pulping hardwood capable of rapid growth along the edges of the canals on the planet Mars—let us say that we will try to discern a reasonable relation between the work of the pulpwood geneticist and of the process development engineer!

Genetic Improvement of Strength

Since the values obtained in applying the various conventional tests of sheet strength (tensile, burst, tear, and fold) appear to be measures of different configurational manifestations of essentially the same group of basic pulp properties, there is good justification for making the initial approach to strength improvement a general one.

It is also clear that whether strength improvement is to be attempted through process development or via genetic modification of the wood itself, it will not get any further than a hit-or-miss approach unless at the outset it is possible to proceed on the basis of good information concerning the factors and behaviors in pulping and papermaking which affect sheet strength. Fortunately, advances in fundamental understanding in this area, especially during the past few years, have been encouraging. It has become possible now to construct a rudimentary motion picture of what happens in pulping and papermaking which has a bearing upon the magnitude of the values recorded when the various conventional types of strength test are applied.

One scene in the moving sequence shows that there are three principal actors, and reveals the progress of relations between them up until the time that the sheet leaves the paper machine. Other scenes show for each of several different measures of strength, what happens in the sheet as stress is being applied and during failure of the sheet. In these scenes, the original three actors are still there, but the viewer's attention is not always drawn to all three.

Leaving the analogy of the motion picture before it becomes strained, let us identify the three actors and convert them back into the three pulp properties which they portray. One is fiber strength—the tensile strength of fibers themselves. Another is a shadowy actor, about whom it is difficult to be as precise as one would like. He (or would we therefore more appropriately say she?) represents the fiber bonding characteristics of the pulp. And the third actor, not difficult to describe, is fiber length.

In the scene which showed what happened in the sheet when its resistance to tearing was being measured, longer fibers or stronger fibers in the sheet made it more resistant to tearing, but increased bonding made it less resistant. When tensile strength, bursting strength, and folding endurance were being measured, however, stronger fibers and better bonding made the sheet more resistant, and increased fiber length had a similar but lesser effect.

The demonstration of these relationships was achieved only recently when reasonably satisfactory methods were devised to measure fiber strength and fiber-bonding capacity.

But the orienting information which both the process developer and the geneticist need in programs to improve strength obviously must go beyond the resolution of pulp influence upon sheet strength into these three principal pulp properties. For pulp properties relate not only forward to sheet properties but also backward to wood properties. And regarding the original wood, the process developer needs to know what—during chipping, pulping, and beating—he

Table I. Pulpwood Properties Considered to Affect Two of the Principal Avenues of Pulp Influence Upon Sheet Strength

Fiber strength	*Bonding characteristics*
Cell-wall dimensions	Hemicellulose content, type, and distribution
Degree of polymerization of cellulose and hemicellulose	Fiber and cell-wall dimensions
Fibril angle in middle layer of secondary wall	

is changing, how he is changing it, and how much he is changing it, in arriving at the fiber strength, fiber length, and fiber-bonding capacity which he can now measure in the pulp. This tracing back into the wood turns out to be intensely interesting also to the pulpwood geneticist, and we find him peering over the process engineer's shoulder because it is the geneticist's job to find or produce trees whose wood properties especially favor, or at the very least do not prejudice, the processor's opportunity to come up with a pulp which in terms of the length and strength of the fibers and their capacity for bonding, will make a sheet having strength properties at desirable levels.

The same range of understanding is thus no less essential to the geneticist. His stock in trade, however, is not control over processing variables; his level of concern and power of choice, by definition, are directed to properties of wood which persist all the way through manufacture in such a way that they influence the strength of the sheet. It is in the tree-to-tree variability of these properties, such as original fiber length and original fiber strength, that the geneticist finds his opportunity, whether by searching the forest, studying hybrids and their offspring, producing polyploids, or by inducing mutations.

But the end is not yet. In actual practice, the geneticist cannot evaluate his samples simply in terms of a measure of fiber strength, a measure of fiber-bonding capacity, and determination of fiber length. Even more urgently than the process developer, he must be able to recognize and measure the more ultimate biologically developed chemical, physical, and anatomical factors in the wood which condition fiber strength and fiber-bonding capacity. For a genetic attack upon any improvement problem is by its very nature an enterprise to identify the more ultimate causes which influence the industrially significant wood properties. These causes or factors may then become the handles to be grasped in the applicational phase of the program. A genetic attack upon fiber strength and fiber-bonding capacity would thus begin with study of certain indicated individual wood factors, such as those listed in Table I, which appear to be influential in some degree.

But lest this enumeration of factors be carried away in a more authoritative way than it is intended, let us point out that a very appropriate alternate title for Table I would be phrased by prefixing the title given, with the words, "Areas for Further Research Regarding the Influence of. . . ."

But even now the geneticist has only started. There still lies ahead further analysis of a wood property into its specific biological determinants and their interrelation. This analysis must always go at least far enough to determine how much the biological expression of the property is influenced by genes, and how much by variable factors in the tree's growth environment. If it is genes which mainly control the variability in the property, and not environmental fluctuation, then intelligence must extend to their level sufficiently to make it clear whether their nature is such that their effects can be expressed just as favorably in future generations produced from seed, and in combination with other wood and tree characteristics judged to be essential.

Genetic studies to throw necessary light on these questions are likely to involve growing one or sometimes more tree generations from seed. Depending upon the intensiveness of genetic approach which appears to be justified, these studies will include progeny (offspring) tests involving various degrees of experimental control over the parent trees employed, and capable of yielding data on relative weights of genetic versus environmental influence upon a character, as well as some indication of the specific mode of gene control over it.

Beyond this, a more protracted program may be indicated which involves bringing the best genes together to enhance a selected property as well as combination of this improvement with other improved wood properties, and with characteristics essential in the tree as a whole. The final testing, involving over-all suitability technically as well as ecologically, whether it has included little or much previous effort, is carried on in the field, in representative growth areas.

In this perspective, one might argue that present-day interest in genetic improvement of strength (and probably equally of other qualities) has come too soon, or that it has come too late. But the same perspective also reveals how the process developer and the geneticist working together, each with a reasonably accurate appreciation of the genius and working circumstances of the other's approach, can now jointly establish "strength potentials" (as well as other property potentials) for the major hardwood pulping species. Thus, for instance, a tensile strength potential for aspen pulp perhaps considerably higher than current mill averages for tensile might be effected by achieving especially favorable combinations of process modification with genetic alteration of pulpwood properties, thus taking the most possible advantage of the influence of both approaches upon fiber strength, fiber-bonding capacity, and fiber length.

Actually, the lack of sufficiently precise definition of improvement objectives for the reference of the pulpwood geneticist is not an occupational hazard peculiar to forest geneticists. Only a few years ago, the president of a cotton-breeding association complained that 15 barren years had elapsed since his cohorts had first asked the manufacturers of the several major lines of cotton textiles to tell them specifically what each of them would like to see in the cotton fiber!

Test Methods

The entering wedge for genetic improvement of pulpwood quality may often be a suitable evaluative method. Testing wood properties in genetic programs requires methods of sampling and evaluation which will permit meaningful, inexpensive evaluation of considerable numbers of small samples removed from living

trees. It appears that a substantial portion of these tests of anatomical, physical, and chemical pulpwood properties may require isolation of the fibers in the wood sample, though some tests do not and others may be found which also do not.

As regards strength, fiber length is not difficult to evaluate but does call for careful methods and may require attention, not only to the average value for the sample, but also to the distribution among size classes. In studies basic to the foregoing account of principal strength relationships between pulp and paper, dependence for measures of fiber strength has been upon the zero-span test (*37*), which appears to be a reasonably accurate method. It provides an estimate of tensile strength and is applied to a sheet, or adaptable for evaluating individual fibers. Bonding capacity is more difficult to measure and presently not so amenable to intensive, well-defined genetic attack.

Several institutions in Europe and the United States are now giving special attention to development of small sample methods suitable for genetic characterization. Formulation of recommendations regarding such tests is one of the charges to the TAPPI Forest Biology Subcommittee on Tests and Quality Objectives.

SUMMARY AND CONCLUSIONS

The nature of a genetic approach is defined in terms of the underlying mechanism of heredity, both as it guides the development of the individual to maturity and as it promotes genetic variety in each new generation, in consequence of the specialized sequence of events which is necessary to accomplish reproduction through seed. A variety of opportunities for practical application of genetic information is suggested.

Significant advance is recognized in essential aspects of forest tree improvement by genetic means, in both fundamental and applied areas and in propagational and evaluative technique. Except for the genus *Populus*, the species involved have been mostly coniferous. Even so, however, there are important carry-over values of a general sort which will facilitate and accelerate genetic improvement programs with hardwoods.

Opportunities for genetic improvement of growth rate and, in more detail, of pulpwood properties are discussed, with emphasis upon the need for both scientific and economic justification when a genetic improvement program is being considered. It appears that wood property improvement ordinarily will not be justified except in programs designed also to achieve improvement in growth rate.

Various physical, chemical, and anatomical variables which may be subject to genetic influence during wood growth are seen to affect three areas of industrial interest, namely, yield of pulp, factors influencing processing cost, and sheet properties which bear importantly upon the use for which the product is intended. A detailed discussion of sheet strength improvement through genetic approach is presented, and is seen to involve some general considerations which would be relevant also in genetic improvement of other sheet properties. This discussion emphasizes the need to proceed on the basis of accurate fundamental acquaintance with the configuration of relevant properties pre-existing in the wood, and with the specific ways in which these properties, as modified in pulping and other processing, are reflected in terms of their influence upon sheet properties. Process development research and genetic improvement research are seen more as complementary to each other than as competitive.

In general, the hardwoods appear to display genetic plasticity and variety of an order which favors exploratory work with a number of species, looking toward possible practical improvement of both tree and wood characteristics. Much, however, seems to depend upon perspicacity in research approach. Thus, there appears to be little room as yet for dogma, in the good sense of the word, except that it does seem to be absolutely true that the initiation and course of genetic programs for pulpwood improvement must reflect regional circumstances and will require one's best judgment regarding what kinds of processes may be used, and what classes of products made, in a given area for some decades to come.

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Penetration and Diffusion into Hardwoods

J. E. STONE and H. V. GREEN

In this review, particular emphasis is laid on the methods which may be used for studying the pore structure of wood as it applies to the penetration of liquids and the diffusion of ions. It is pointed out that the penetration of liquids into hardwoods is entirely dependent on the presence of vessels, with the fibers contributing little or nothing to liquid flow. The result of this is that liquid flow (penetration) across the grain is negligible. A further result of flow being confined to vessels is that rates of penetration into hardwoods show wide variations, being very rapid when the vessels are open and extremely slow when they are plugged by tyloses. A separate and distinct mechanism for the movement of chemical into wood is ionic diffusion. Diffusion of ions can occur across the cell wall itself and is not dependent on the presence of vessels, nor is it dependent on the absence of tyloses. It depends, so far as wood structure is concerned, on the total cross-sectional area of the diffusion paths, which in turn depends on direction relative to the grain, on wood density, and on swelling of the cell wall by alkaline reagents. Diffusion, however, is a much less variable mechanism than penetration, and when the wood has a high moisture content and the distances involved are small it is a method for transporting chemical into wood which probably has a wider application than penetration.

Much of the work which has been carried out on penetration and diffusion into wood has been concerned with a study of operating variables such as temperature, pressure, pH, viscosity of liquor, etc., and the effect of such pretreatments as steaming, purging, or evacuation. To review this work in its entirety would be an enormous task and will not be attempted here. The chief reason is that a considerable amount of the work reported in the literature has been concerned with coniferous woods and is only pertinent to the present discussion in the sense that deciduous and coniferous woods are both porous media of lignocellulose material and will necessarily respond in the same way to the laws of capillary flow and ionic diffusion. The capillary structure of hardwoods is sufficiently different from that of softwoods, however, that each must be considered separately. In this discussion therefore, the emphasis is not on penetration and diffusion as such, but on penetration and diffusion as they apply to hardwoods.

J. E. Stone, Head, Division S, and H. V. Green, Chief, Photomicrography Section, Pulp and Paper Research Institute of Canada, Montreal, Que.

DISTINCTION BETWEEN PENETRATION AND DIFFUSION

It is important at the outset of this paper to make a clear distinction between the terms "penetration" and "diffusion." Penetration is the movement of liquid into the capillaries of wood under the influence of a pressure gradient. This mechanism can be extremely rapid under favorable conditions and permits, for example, the penetration of 4-ft. logs in a few minutes, as in the chemigroundwood pulping process. Diffusion, on the other hand, refers to the movement of ions through water under the influence of a concentration gradient, and is a comparatively slow process, being quite incapable of transferring chemical into a piece of wood as large as a 4-ft. log in a reasonable time.

Apart from the difference in rate there are many other practical differences between the two mechanisms which it is essential to bear in mind when considering a problem in this field. Some of these differences will be summarized at the end of this paper, but the important thing at this point is to recognize that two distinct mechanisms exist.

NECESSITY FOR UNIFORM PENETRATION

The objective in pulping is to dissolve lignin and some carbohydrates from the middle lamella and cell walls of the fibers in order to permit fiber separation and impart desirable physical properties to the fibers. Ideally, each fiber in a piece of wood that is being pulped should receive the same chemical treatment, and this involves immersion in a pulping liquor of the same concentration, at the same temperature, and for the same time. Since an average hardwood chip contains several million fibers, interconnected by a

very complicated series-parallel arrangement of capillaries varying in diameter many thousandfold, it is perhaps not suprising that the interior of a wood chip is sometimes found to be undercooked.

RESULT OF POOR PENETRATION AND DIFFUSION

Nonuniformity in pulping due to inadequate penetration and diffusion shows up in several ways. One is

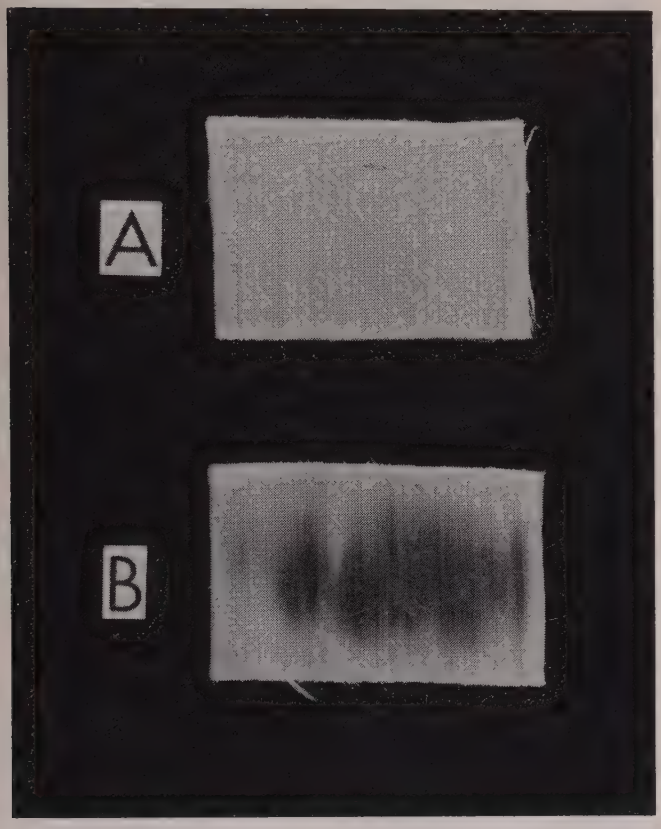

Fig. 1. Result of poor penetration. Neutral sulphite pulping of aspen showing, A, uniformly penetrated chip; B, burnt-centered chip

the "burning" which occurs when wood is heated in the absence of pulping chemical. This is shown in Fig. 1.

The burning is most easily seen when a neutral or acid sulphite cooking liquor is used, since the properly penetrated wood is white in this case, but there is no reason why wood chips cooked in an alkaline liquor should not burn also. It would be very much less obvious in the case of an alkaline cook, however, since the penetrated and cooked outer layers are much the same color as the burnt center. In an alkaline cook a poor penetration of cooking liquor is seen most clearly by the white centers which occur in the early stages of a cook when insufficient time has elapsed for the temperature in the interior of the chip to have risen to the point where burning occurs. An example of white-centered alkaline-cooked chips is shown in Fig. 2.

Although the presence of dark- or light-centered chips can be taken as evidence of nonuniformity, their absence does not constitute proof that the distribution of heat and cooking chemical throughout the chip was satisfactory. In a sulphite or neutral sulphite cook, for example, sufficient chemical might have reached the center of a chip to prevent burning, but the concentration might be so much lower at the center than the outside, and the temperature might also be lower, so that the center is cooked less than the outside. This is a fairly common occurrence and can be recognized by the high percentage of screening rejects which are produced when the cooked chips are disintegrated. These rejects consist of fiber bundles from the center of the chip which did not separate into individual fibers because of insufficient cooking.

If nonuniformly cooked chips are passed through a refiner—common practice with high yield pulps—the presence of undercooked centers may not show up as screening rejects, since the harder centers may be fiberized by the refiner to the point where they pass through the screen plate. In a case like this, about the only way in which nonuniform cooking would show up is in the lower strength characteristics of the paper made from the pulp when compared with pulp from uniformly cooked wood.

From the compositional point of view, burning will lower the carbohydrate content of a pulp without a corresponding lignin removal. The pulp will therefore have an abnormally high lignin content for the yield of fiber obtained. Burning, in fact, corresponds to prehydrolysis of the wood in the center of the chip, and as in prehydrolysis the pentosans are hydrolysed to water-soluble compounds, and lost to the pulp.

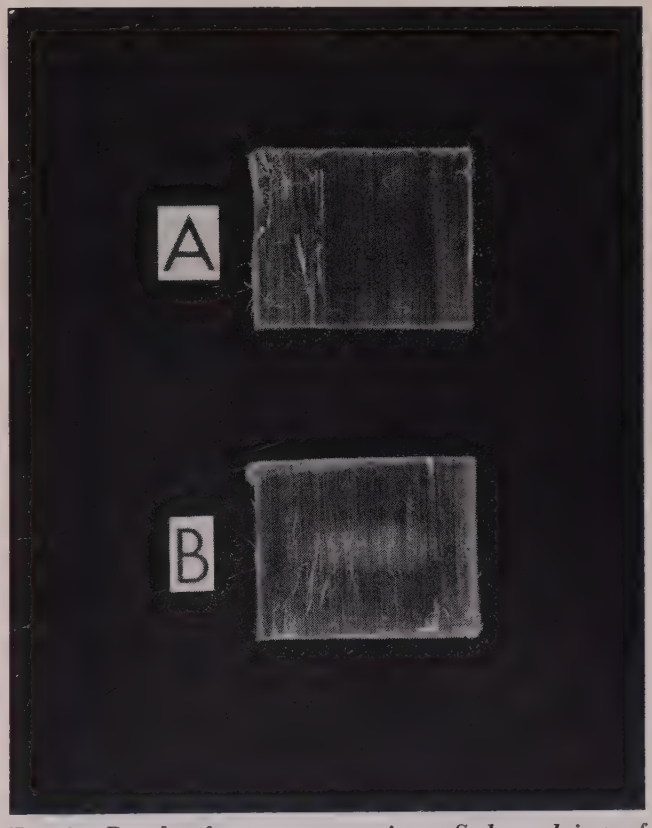

Fig. 2. Result of poor penetration. Soda pulping of aspen showing, A, uniformly penetrated chip; B, white-centered chip

The cellulose will also be affected adversely and have a lower degree of polymerization.

When the nonuniformity of pulping does not involve burning, but only the production of chips with hard centers, the result is a mixture of pulps varying from low yield at the outside of the chip to high yield at the

center. Such a mixture may not have an over-all composition greatly different from that of uniformly cooked wood of the same yield, but bleaching may be adversely affected since the chlorine demand will differ for different fibers, depending on their location in the original chip.

In summarizing this section therefore, poor penetration and diffusion may be recognized by (1) visual examination of a cooked chip, (2) percentage of screening rejects, (3) pulp quality, and (4) chemical composition.

CAPILLARY STRUCTURE OF HARDWOODS

The structure of hardwoods is too well known to be discussed in detail here. It is necessary to say a few words, however, about wood structure from the penetration and diffusion point of view. In Fig. 3 is shown a cross section of poplar and the characteristic pattern of small fibers and large vessels may be seen. The objective in pulping is to attack and dissolve the material lying between all the fibers, i.e., the middle lamella, and the question which needs answering is: How does the cooking chemical reach a middle lamella such as that marked "A" in Fig. 3. situated at the center of a wood chip and midway between two vessels? This is presumably the most difficult point to reach, and as we have seen in Figs. 1 and 2 it is not always reached successfully.

The most obvious route for the liquor to take in its journey from the outside of the chip to point A is along a vessel, through a pit system joining the vessel to the surrounding fibers, and then via fiber lumen,

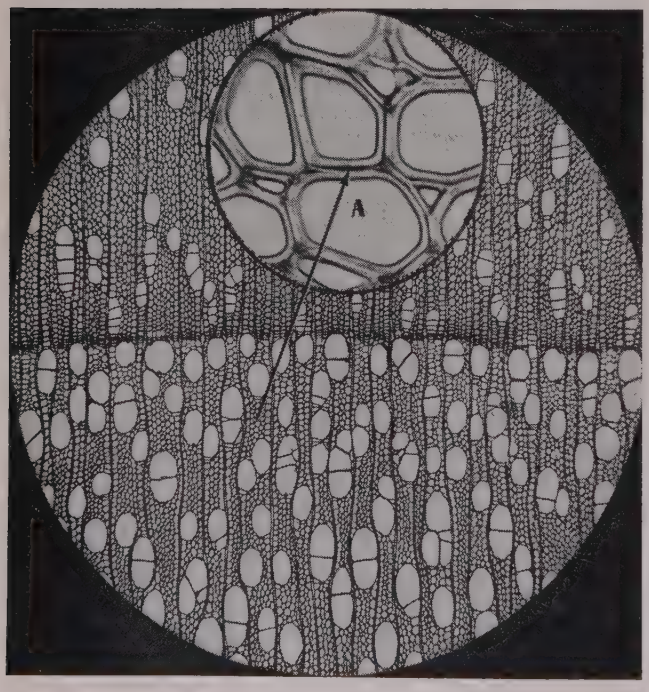

Fig. 3. Cross section of aspen

pit, fiber lumen, etc., to the fiber most remote from the vessel. From the lumen of any fiber to the adjacent middle lamella, the chemical could either travel by diffusion through the cell wall or eat its way down between the fibers starting at a pit membrane. An alternative route would be lengthwise from fiber to fiber via the pit systems, not utilizing the vessels. Another possibility would be the movement of liquor along the middle lamella from the outside to the interior, i.e., between the fibers rather than through them. Unfortunately, none of these mechanisms is satisfactory for explaining certain observable facts in

Fig. 4. Longitudinal section of aspen, part sapwood and part heartwood, showing tyloses in the latter

connection with the pulping of hardwoods, and it is necessary therefore to hypothesize. The hypothesis is this: the fibers of hardwoods do not permit liquid flow. Flow is restricted entirely to the vessels and chemical moves into hardwood fibers solely by a diffusion mechanism. This hypothesis will be supported later by experimental evidence.

Vessels

From the penetration point of view, the most important anatomical feature of hardwoods is the vessels. These capillaries run for a more or less indefinite distance in the longitudinal direction and when unplugged by tyloses are extremely effective channels for transporting chemical into the interior of the wood. In the chemigroundwood process, logs 4 ft. long and over a foot in diameter are penetrated with neutral sulphite liquor by pulling a vacuum for 30 min., flooding with liquor, and applying 150 p.s.i. hydrostatic pressure. When the vessels are open this treatment is very effective and the liquor enters the wood so readily that the bulk of the penetration is completed in just a few minutes. Softwoods, being devoid of vessels, cannot be satisfactorily treated in this way.

The number, diameter, and distribution of vessels varies considerably from species to species. In ring porous woods, for example, they are concentrated in the early wood, whereas in diffuse porous woods they are

more uniformly distributed over the annual ring. This will, no doubt, effect the penetration characteristics of a given wood.

Tyloses

Vessels, unfortunately, have the nasty habit of becoming plugged with cyloses, and depending on the extent of tylosis formation, vessels become more or less useless for liquid flow. In Fig. 4 is shown a section of poplar comprising part sapwood and part heartwood, and the tylosic membranes can be clearly seen in the heartwood vessels. The result of cooking wood such as this may be seen in Fig. 5 which is a chip of poplarwood, half heartwood and half sapwood, which was impregnated with NSSC liquor, cooked for

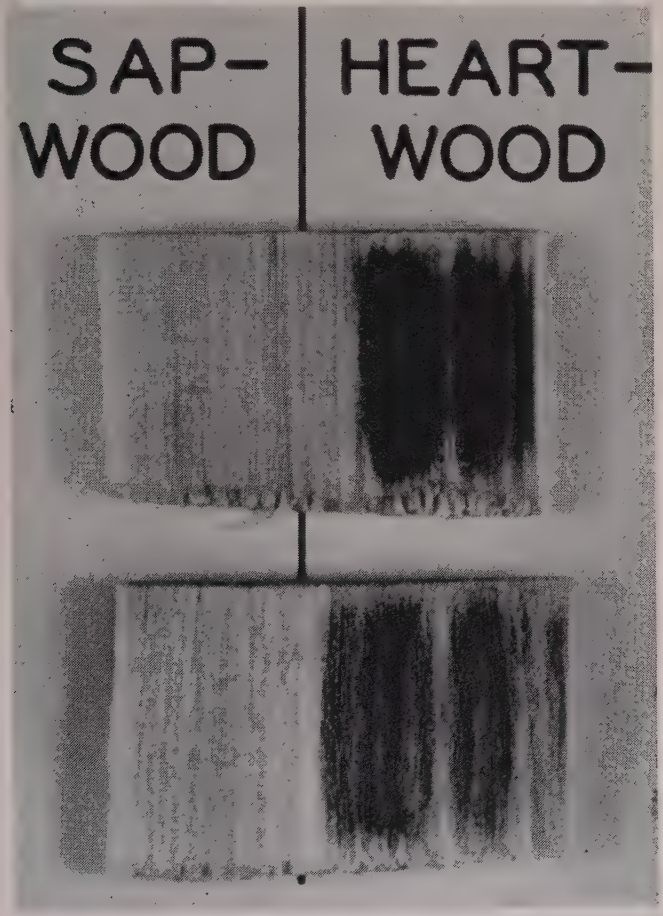

Fig. 5. Cooked aspen chip, part sapwood and part heartwood, showing burning in heartwood

40 min. at 170°C. and split open to show the burning which occurs where tyloses are present. A section of beech heartwood is shown in Fig. 6 and the tyloses are seen to be very numerous. A disk of beech heartwood after cooking in NSSC liquor is shown in Fig. 7 and concentric rings of burnt and unburnt wood are clearly seen. Wood from the light and dark areas was examined microscopically but no difference could be seen between them. Both regions were heavily infested with tyloses. The figure has been included because it demonstrates two things. One is the variability of wood. The other is the danger of predicting the permeability of wood from microscopic examination.

What are tyloses? Tyloses are bladderlike growths

Fig. 6. Tyloses in beech heartwood

in the vessel cavities caused by adjacent parenchyma cells growing through the pit membranes and enlarging to fill or partly fill the vessel. In Figs. 8, 9, and 10 tyloses are seen in various stages of development from small buds growing out from a ray parenchyma to the

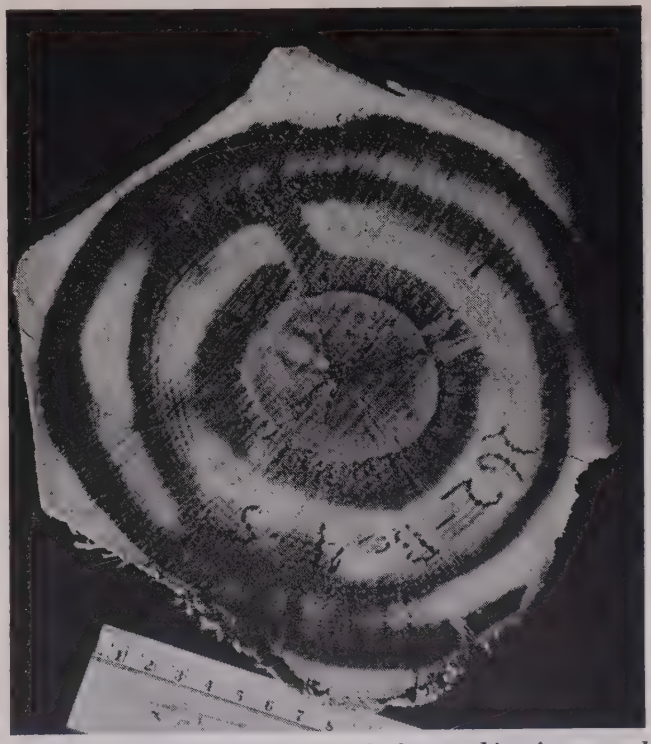

Fig. 7. Disk of beech heartwood after cooking in neutral sulphite liquor

Fig. 8. Tylose formation in aspen. Early stage

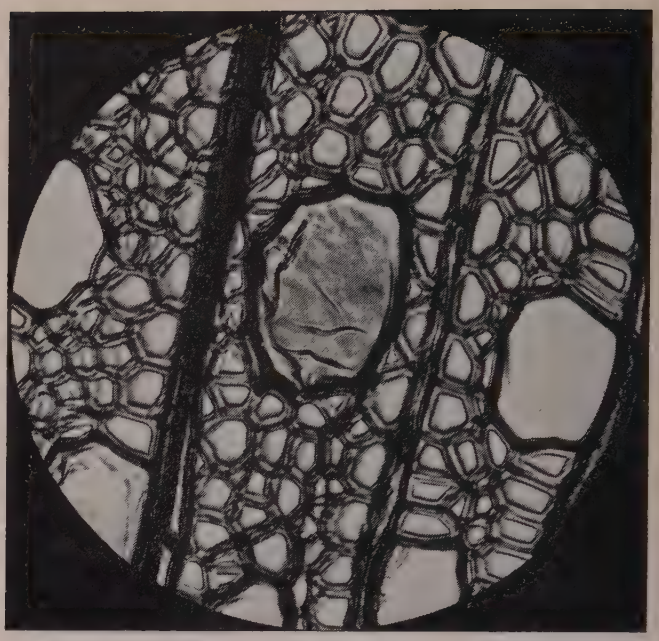

Fig. 10 Tylose formation in aspen. Final stage

fully developed balloons which they ultimately form. In Figs. 11 and 12 tyloses can be seen in isolated vessel segments, and in Fig. 13 an isolated tylosis is shown.

The amount, character, and distribution of tyloses in a hardwood varies considerably from species to species, and each species must be treated as a separate problem in penetration. When examination shows that tyloses are present the chances are good that penetration will be poorer than when they are absent, but quantitative predictions cannot be made.

Fibers

Since, in pulping, the vessels are merely channels into the interior of the wood and it is the fibers that are the structures of chief importance to the papermaker, it would be appropriate to discuss the capillary structure of fibers. Unfortunately, there is little which can be said about them. The cell walls themselves do not permit liquid flow. The only possible passages for liquid flow are the pit membrane pores, and direct observation is not capable of determining their effectiveness. Hardwood pits are smaller and fewer in number than in softwood tracheids, so it might be expected that they would be less effective for liquid movement, but it is the pit membrane pores which are the rate controlling structures and these are so small and probably so variable that it is necessary to rely on indirect evidence rather than direct observation for determining the role they play in penetration.

Diffusion Paths

As far as the diffusion of ions is concerned, diffusion takes place into water and will normally occur wherever water is present. This includes the cell wall itself, the pit membranes, and the vessel and fiber cavities when the moisture content of the wood is above the fiber saturation point. The cell wall capillaries which permit ionic diffusion are not visible microscopically

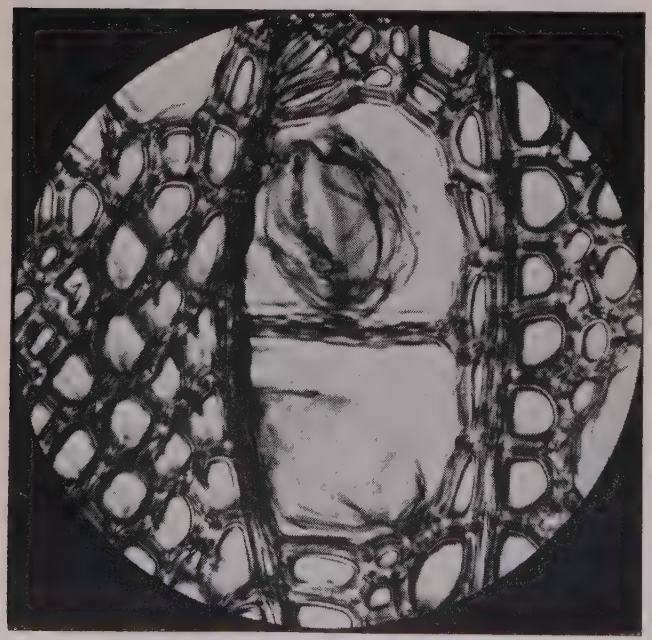

Fig. 9. Tylose formation in aspen. Intermediate stage

Fig. 11. Tylosis in isolated vessel segment

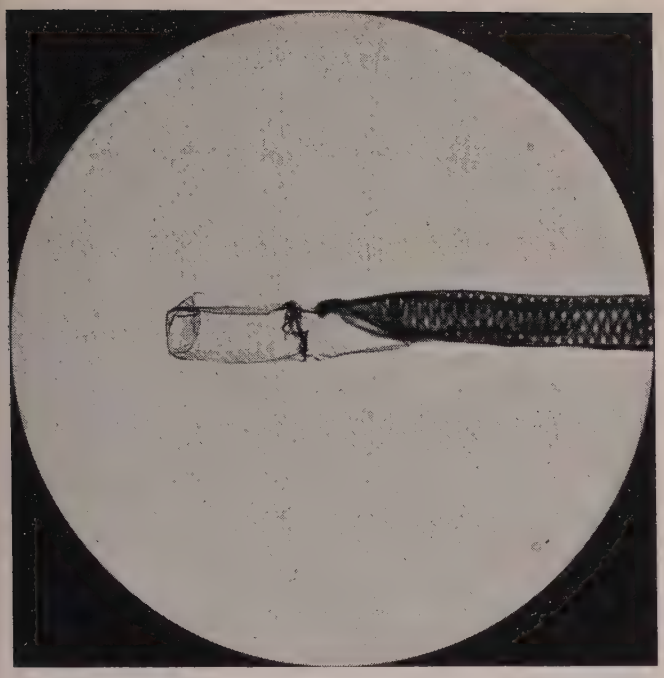

Fig. 12. Tylosis in isolated vessel segment

and their existence must be inferred from the ability of ions to diffuse through water-swollen wood in all three of the structural directions.

MEASUREMENT OF POROSITY (FOR PENETRATION)

There are many methods for measuring the rate at which liquids or gases will flow through wood. A block of wood can be clamped in a special cell and water (*7, 21*) or air (*13, 18, 19*) forced through it. A simple test is the measurement of sinkage time (*6, 9, 14, 15, 16, 19*), this test consisting of the immersion of the block under water either before or after the evacuation of air, and measuring the time for the blocks to sink. A refinement of this test is the use of a quartz helix to measure continuously the change in buoyancy of the sample as water enters the pores (*12, 22*).

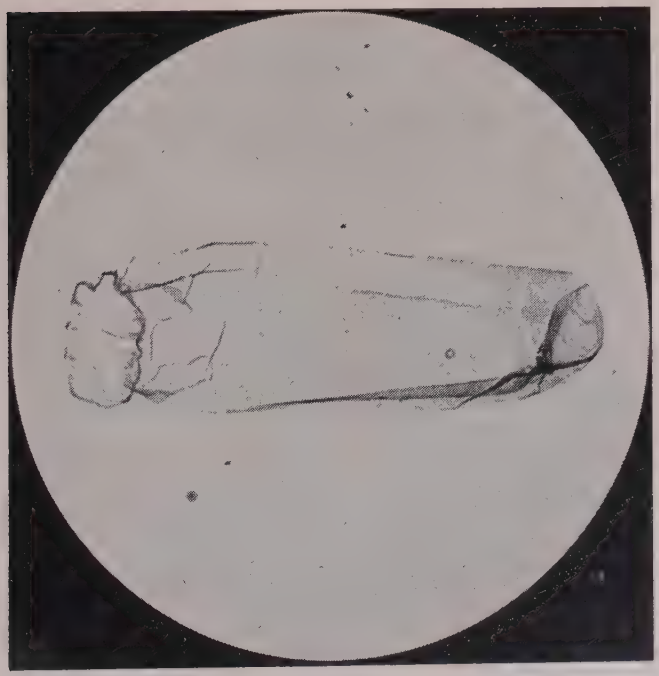

Fig. 13. An isolated tylosis from aspen

Table I. Sinkage Time for Several Hardwoods

Species	*Specific gravity*	*No. trees sampled*	*Sinkage time, min.*		
			Sapwood	*Heartwood*	
Aspen (*P. tremuloides*)	0.33	35	Min. 3	1,800	
			Max. 9	42,000	
			Av. 5	12,000	(8 days)
Beech (*F. Grandifolia*)	0.5–0.6	35	Min. 0.1	1	
			Max. 0.5	5,000	
			Av. 0.1	700	(12 hr.)
Birch (*B. Papyrifera*)	0.5–0.6	40	Min. 2	3	
			Max. 5	60	
			Av. 3	16	

A few results obtained (*19*) on hardwoods with the sinkage time method are shown in Table I.

The factors governing flow through a capillary are given by the Poiseuille equation:

$$\frac{V}{t} \alpha \frac{nr^4 \Delta P}{L}$$

The volume V which flows through n capillaries in time t is proportional to the fourth power of the radius of the capillaries, to the pressure drop ΔP, and inversely proportional to the viscosity of the fluid η and the length of the capillary L. The terms n, r, and L are obviously factors related to wood structure, whereas the viscosity term η is characteristic of the liquor being used and ΔP is concerned with operating conditions, i.e., the pressure differential. A general statement which can be made at this point therefore is that the rate of flow will be greatest when there are a large number of capillaries, short in length and large in radius, being penetrated with liquor of low viscosity under a high pressure differential. Some of these factors are under our control and some are not. Thus, we can reduce L by cutting the wood into small pieces. The driving pressure ΔP can be increased at will within the limits of the digester and aided by evacuating air from the wood to reduce the back pressure. The viscosity η is more or less fixed by the fact that water is the liquid used in pulping, but the viscosity decreases with increasing temperature, and at 150°C. is only about 20% that at room temperature. Not under our control are n, the number of capillaries per unit area and r their average effective radius. These are clearly determined by the structure of the wood and since r is raised to the 4th power it might be expected to be the most important single factor.

A method of measuring the permeability of wood and the classification of different species in terms of a porosity factor has been mentioned elsewhere (*19*) but will be repeated here for the sake of completeness. The method is this: the rate at which air will flow

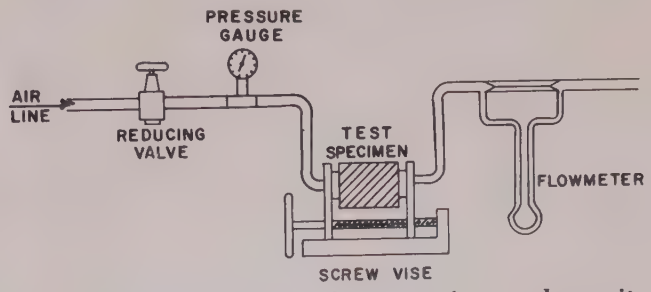

Fig. 14. Air flow apparatus for measuring wood porosity (13)

Table II. Permeability[a] of Two *Populus* Species

Position	Height above ground, m.	*P. nigra* North	*P. nigra* South	*P. nigra* East	*P. nigra* West	*P. alba* North	*P. alba* South	*P. alba* East	*P. alba* West
Close to pith	0	2900	257	750	325	48	0.85	121	46
	2	1600	600	...	1180	110	0.94	0.18	65
	6	5000	2550	22	3900	...	0.70	2.7	11
Middle	0	309	717	84	431	446	34	1300	53
	2	3730	665	64	3940	106	4.3	232	251
	6	...	...	...	1350	...	...	...	...
Close to bark	0	50	607	...	89	0.6	47	1050	3200
	2	151	20	109	590	274	223	...	1540
	6	42	433	21	115	4.0	834	114	175

[a] Porosity coefficient $r^4 \times 10^{-10}$ cm.

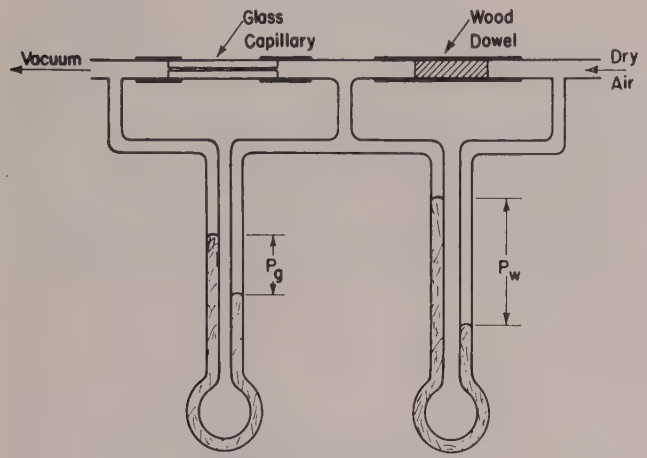

Fig. 15. Air flow apparatus for measuring wood porosity (19)

through 1 sq. cm. of wood under a given driving force is determined. The porosity of the wood is then defined as the 4th power of the radius of a single capillary which would permit the same rate of flow. The advantages of using air rather than water are: (1) it is simpler experimentally, (2) the low viscosity of air compared with water leads to a reasonable rate of flow, and (3) it is very difficult to reach equilibrium using water. As far as apparatus for measuring the flow of air through wood is concerned, perhaps the simplest is some such device as that used by Paul (*13*) for measuring the porosity of 12 species of oak. It is shown in Fig. 14.

Stamm (*18*) and Stone (*19*) used the apparatus shown in Fig. 15 which consists of two flowmeters in series, the restriction in one being a glass capillary of known length and bore, and the restriction in the other being a wood dowel of known dimensions. The pressure drop ratio obtained with this apparatus is proportional to the porosity of the wood.

Another simple apparatus is shown in Fig. 16. Liquid runs from the reservoir through the leg at a rate which depends on the rate at which air can flow into the reservoir through the wood dowel. The lowering of pressure above the liquid is measured with a manometer, and the rate of flow measured by weighing the liquid which runs out in a given time.

Some results obtained with these apparatuses are shown in Tables II and III. In Table II is given the result of a study of the porosity of *P. alba* and *P. nigra*, measurements being made close to the pith, close to the bark, and midway, at 0, 2, and 6 m. above the ground and on the north, south, east, and west sides of the tree. A single tree of each species was used. It is seen that there is a very considerable variation in porosity between the samples taken from a single tree and there is no correlation between porosity and position in the tree. It is obviously impossible to assign a definite porosity to these species, but qualitatively at least it is possible to say that the heartwood of *P. alba* is, on the average, much less porous than the heartwood of *P. nigra*. In Table III the porosity of a number of hardwoods is shown and the wide variation between species and between sapwood and heartwood is seen. Even though we know that there exist extreme differences in porosity of samples taken from adjacent parts of the same tree, the results shown in the table do, in fact, confirm certain well-known observations, e.g., that white oak is less porous than red oak, and beech and aspen heartwood are less porous than the corresponding sapwoods.

The fairly good agreement between sinkage time

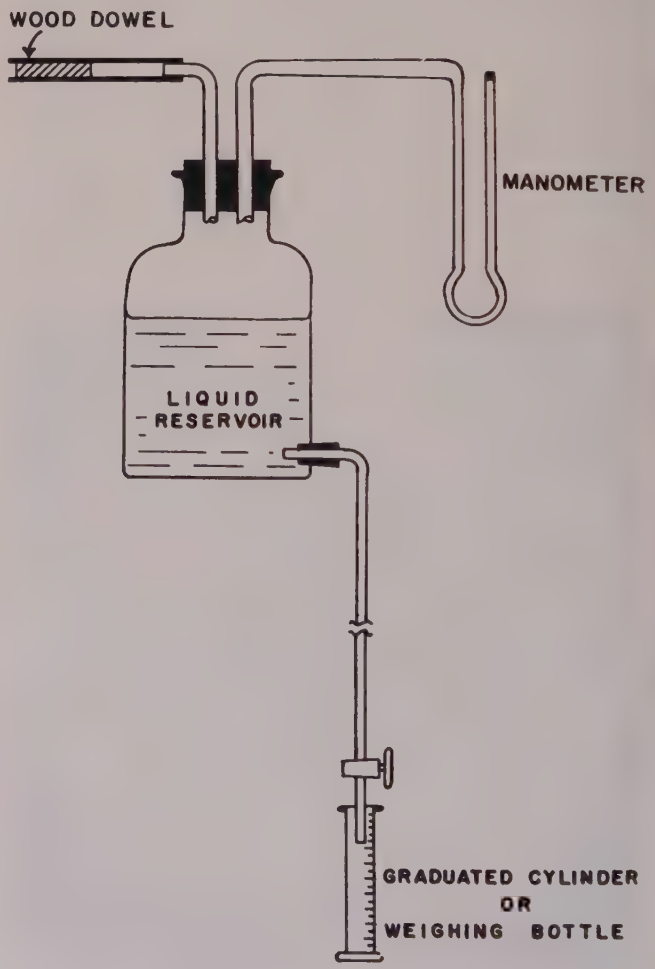

Fig. 16. Air flow apparatus for measuring wood porosity

Table III. Variation of Penetrability Between Species

Species	Penetration factor × 10^{-10} Sapwood	Heartwood
Elm (*Ulmus Americana*)	400	70
Box elder (*Acer negundo*)	1300	400
Hickory (*Carya ?*)	4000	400
Sycamore (*Platanus occidentalis*)	4000	4000
Willow (*Salix nigra*)	4000	...
Birch (*Betula papyrifera*)	1300	450
Beech (*F. Grandifolia*	1000	0.5
Sweetgum (*Liquidambar styraciflua*)	1200	850
Ash (*Fraxinus nigra*)	80	...
Maple (*Acer rubrum*)	400	120
Red oak (*Quercus falcata*)	4000	5
Scarlet oak (*Quercus coccinea*)	1000	400
Post oak (*Quercus stellata*)	67	5
White oak (*Quercus alba*)	0.7	...
Cottonwood (*P. Deltoides*)	4000	500
Balm of Gilead (*P. Tacamahaca*)	800	300
Aspen (*P. Tremuloides*)	2500	1
Aspen (Finland) (*P. Tremula*)	5000	4
Triploid Aspen (Finland) (*P. Tremula*)	1000	2000

and air flow methods for measuring wood porosity may be seen from Table IV. Both methods give similar ratios of sapwood to heartwood porosity when the average values for a given species are compared and tends to justify the use of air instead of water for measuring porosity. It may be argued that wood which is swollen by water may be more permeable than wood in the oven-dry condition since the swelling may open up the pores. Measurements made with air on dry wood may therefore give a false picture of the permeability of the wood to aqueous solutions. However, it has been shown by Buckman, Schmitz, and Gortner (*2*) and by Stamm (*18*) that the pit membrane pores in softwoods become less permeable as the moisture content rises from zero to the fiber saturation point. The use of air will therefore tend to give high values for porosity rather than low.

Of more fundamental interest than the variation in porosity between species or location in the tree is the result obtained when the porosity at right angles to the grain direction is measured. A dowel was drilled from a low density, very porous wood (aspen sapwood) with the axis of the dowel at right angles to the grain direction. When connected to any of the air-flow apparatuses mentioned above it was found that the rate of flow was essentially zero. Several other woods were tried (oak, maple, birch) and the rate of flow of air perpendicular to the grain direction was found to be of the order of 10^{-3} that which is obtained with a very difficultly penetrated wood such as beech heartwood in the grain direction, and 10^{-6} that of an easily penetrated wood in the grain direction. In other words, for all practical purposes the hardwoods which have been studied are completely impenetrable across the grain.

MEASUREMENT OF CAPILLARITY FOR DIFFUSION

There are two general methods for measuring the diffusion paths through wood. One involves the

Table IV. Comparison of Two Methods for Measuring Wood Porosity

	Ratio of sapwood: heartwood porosity — Sinkage time	Air permeability
Aspen	2400	2000
Beech	7000	2000
Birch	5	3

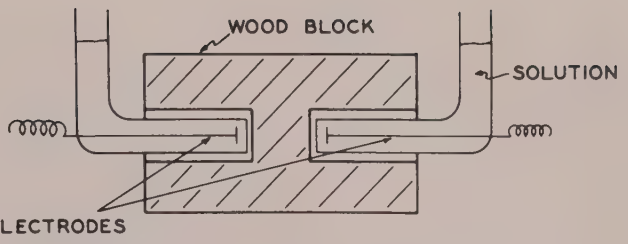

Fig. 17. Measurement of diffusion paths through wood by means of conductivity

classical methods of measuring the rate at which ions will diffuse through a wood membrane from a solution on one side of the membrane, to a solution of lower concentration (or water) on the other side. Alternatively, blocks of wood are saturated with water, immersed in a salt solution and the blocks sectioned and analyzed for the salt after a period of time. These methods have been used particularly for studying the effect of ionic size or charge, pH, molecular size and shape, etc. (*1, 4, 5, 8, 10, 11*).

The second general method involves the saturation of the wood with a salt solution and measuring the electrical conductivity through the wood (*3, 17, 20*). By comparing the conductivity obtained with the conductivity of the same solution with no wood present, a direct measure is obtained of the cross-sectional area of the paths available for ionic conduction. It is assumed that these are the same paths which are available for ionic diffusion.

For conductivity measurements the apparatus shown in Fig. 17 is both simple and effective. Its use is described elsewhere (*20*). If the resistance between the electrodes in the presence of wood is R_w and in the absence of wood is R_o the effective capillary cross-sectional area is R_o/R_w. Results obtained with aspen saturated with potassium chloride are shown in Table V. It is seen that in the grain direction the diffusion paths constitute 47% of the total cross-sectional area of the wood. In the radial direction it is 11% and tangentially is 6.6%. The values vary somewhat with species, wood density, etc. but on the average the resistance to the passage of ions in the cross-grain directions is of the order of ten times that in the grain direction. This may be compared with the many thousandfold difference in penetration rates.

A word must be said about the effect of pH. It is not uncommon to read the statement that alkaline solutions penetrate wood at equal rates in all directions. In the sense that the term "penetration" is used here this is definitely not the case. Alkaline solutions do *not* penetrate wood at equal rates in all directions, neither do they penetrate more rapidly than acid solutions. They do, however, *diffuse* at approximately equal rates in the three structural directions of wood, as demonstrated in Fig. 18. The data plotted in Fig. 18 were obtained by the conductivity method and

Table V. Effective Capillary Cross-sectional Area of Aspen (0.1 *M* KCl)

Dry thickness of membrane, in.	Longitudinal	Radial	Tangential
0.104	0.48	0.11	0.066
0.145	0.47	0.11	0.065
0.236	0.46	0.11	0.067
0.278	0.47	0.11	0.065

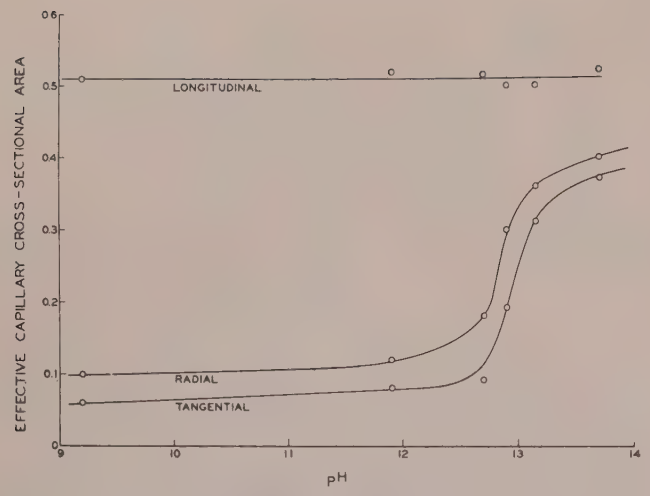

Fig. 18. Affective capillary cross-sectional area of aspen. Effect of pH

show that in strongly alkaline solutions the cell walls of aspen swell to the point where the area of the diffusion paths normal to the fiber axis approaches that in the axial direction. The data also show that only the most strongly alkaline solutions are effective in increasing the area of diffusion paths.

THE PATH OF CHEMICAL MOVEMENT THROUGH HARDWOODS

Referring back to Fig. 3 and the question that was raised at the beginning, "How does the chemical reach point A?," it is now possible to attempt an answer. It is hypothesized that liquid movement, i.e., penetration, occurs through the vessels to the interior of the wood. No liquid moves as such through hardwoods in the cross-grain direction, neither does it move lengthwise through the fibers, or transversely through the fibers, radially from the vessels. The fibers are believed to be totally enclosed cells, with no passages for liquid movement. Chemical reaches the fibers and the middle lamella between fibers solely by a diffusional mechanism, water vapor diffusing ahead of the ions where necessary and providing diffusion paths for subsequent ionic movement.

The argument is as follows: actual measurement with air has shown in the case of the hardwoods examined that flow rates are negligibly small at right angles to the grain. Pulping chemicals must, however, move at right angles to the grain when hardwoods are pulped because the fibers are radially disposed around the vessels, and chemical is obliged to move from vessel to surrounding fibers by penetration or diffusion at right angles to the fiber axis. If penetration (i.e., liquid flow) were involved, the liquor would need to flow through many pit systems in series in order to reach the fibers situated midway between two vessels. Figure 19 (see also Fig. 5) however shows that pulping liquor is incapable of flowing through more than one or two pit systems in series. Figure 19 is a chip of aspen heartwood in which the vessels are plugged by tyloses, and it will be observed that burning occurs to within about a millimeter of the end grain. Presumably the presence of tyloses in the vessels does not influence the permeability of the pit membrane pores in the fibers, and yet chemical was only capable of moving a distance equivalent to the length of one or two fibers in the fiber direction. If flow were involved, this implies that liquor could only flow through one or two pit systems in series. It has already been seen in the case of sapwood, however, that chemical is capable of moving through many fibers in series in the transverse direction. Flow through the pits is therefore not involved.

Diffusion is not dependent on pits but only on the total cross-sectional area of the diffusion paths and the distance to be traveled by the ions. In the fiber direction the chemical moved about 1 mm. (Fig. 19) and the effective capillary cross-sectional area is about 0.5. In the transverse direction the effective capillary cross-sectional area is about 0.1 so it might be expected that in this direction the chemical could travel about one—fifth the distance in the fiber direction, i.e., about 0.2 mm. This is sufficient to cover the distance between a vessel and the fibers situated midway between two vessels. A diffusion mechanism through the fibers is therefore a sufficient explanation for the observed facts.

If this hypothesis is correct it suggests that the optimum moisture conditions in a hardwood prior to pulping (assuming the vessels are open and available for flow) would be where the fibers are water saturated and the vessels empty. Liquor could then flow into the interior of the wood via the vessels and the chemical diffuse radially from the vessels into the surrounding fiber through the water present in the fiber lumen and walls. Since it is probably difficult in practice to have fibers filled and vessels empty of water, wood at the fiber saturation point would be the practical alternative. In other words, oven-dry wood is not in the best state for pulping, since the dry fiber walls hinder diffusion of chemical from the vessels. If the vessels are plugged by tyloses so that no penetration can occur, the wood should be water saturated to provide optimum conditions for diffusion.

Another consequence of the hypothesis that hardwood fibers are ineffective for liquid flow is that the distribution and number of sessels in a hardwood might be of considerable importance in pulping. Thus, in ring porous wood there are areas containing few vessels and chemical would need to diffuse over considerable distances. Such woods may require longer "times-to-temperature" during pulping than diffuse porous woods, in order to allow time for the slow diffusion mechanism to transport chemical over the comparatively large distances from the vessels.

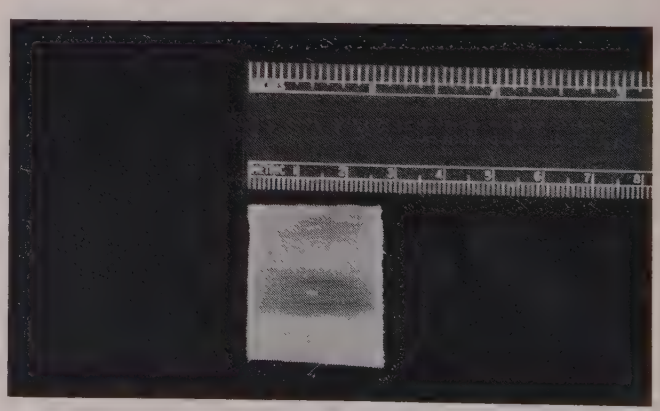

Fig. 19. Cooked chip of aspen heartwood, showing very small distance traveled by pulping chemical in the fiber direction. See also Fig. 5

Table VI

Penetration	*Diffusion*
Occurs through vessels	Occurs wherever water is present
Optimum in comparatively dry wood	Optimum in water-saturated wood
Effective over very large distances in grain direction	Only effective over short distances
Noneffective across grain	Effective across grain
Extreme differences in rate observed between: (a) sapwood and heartwood; (b) different hardwood species; (c) softwoods and hardwoods	Small differences between different woods
Unaffected by wood density	Affected by wood density
Composition of liquor of small importance	Strongly affected by liquor composition

SUMMARY

The factors influencing penetration and diffusion in hardwoods are probably best seen by comparing and contrasting the two mechanisms for chemical movement, as in Table VI.

Hardwoods behave quite differently from softwoods as far as the penetration of liquid is concerned, the differences being due to the presence of vessels in hardwoods, which, when unplugged by tyloses, permit rapid penetration into the interior of large pieces of wood. The difference is further emphasized by the inability of hardwood fibers to allow liquid flow, in contrast to softwood tracheids, the result being that no flow can occur transversely through hardwoods, chemical movement being restricted to a diffusion mechanism.

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Development of High Purity Dissolving Wood Pulp for Tire Cord Production

CHARLES SCHENKER and MERLE A. HEATH

Technological advancement in the viscose tire cord industry and need for a broader and economically stable source of raw material were incentives to develop a dissolving grade wood pulp at a new commercial level of chemical purity. The resulting process is outlined and comparisons are made with the established purified second-cut cotton linters cellulose with regard to chemical properties, chain length distribution, caustic solubility of the aged alkali cellulose, supermolecular structure, viscose processing, and final tire yarn properties.

The past three years have seen a period of tremendous advancement in spinning technology in the tire cord industry. Cords are being produced commercially today that were only research-laboratory or semiworks-scale accomplishments five years ago (*1*). As a part of this development, the chemical pulp industry has been stimulated to provide improved cellulosic starting materials. Individual and cooperative programs have been undertaken in an attempt to correlate pulp characteristics with properties of the final yarn (*2–4*) and to select those with favorable significance for process modifications. For regenerated cellulose yarn to maintain its predominant position in the tire cord field a uniform, stable, economically competitive source of cellulose, suitable in quality and properties for any technological advance in processing, is a basic requirement.

The two practical sources of cellulose for chemical purposes in this country are cotton linters and wood pulp. Cotton linters was first to be used in the production of tire cord by the viscose process, and for many years has been the preferred supply. It was generally accepted, on the basis of testing and experience, that it gave a superior product compared to the wood pulps that were available. However, as an annual crop, and a by-product of the cotton seed oil industry, it had economic disadvantages in the mounting competition with entirely synthetic yarn. To insure tire cord pulp pure stability, a second and more plenti-

Charles Schenker, Associate Director, Products; Merle A. Heath, Technical Service Section, Tech. Div., The Buckeye Cellulose Corp., Memphis, Tenn.

Table I. Chemical Properties of Pulps from Variations in Tire Cord Grade Process

Pulp sample →	*A*	*B*	*C*	*D*	*E*	*F*
Alpha-cellulose						
Type	Low	Low	Low	Low	High	High
%	96.7	97.1	96.1	96.4	98.3	99.1
Beta-cellulose, %	2.7	2.0	2.5	2.1	1.2	0.7
Gamma-cellulose, %	0.7	1.0	1.5	1.5	0.5	0.3
Pentosans						
Type	Low	Low	High	High	Low	Low
%	0.5	0.6	1.3	1.6	0.5	0.5
Viscosity						
Type	Low	High	Low	High	Low	High
(0.5% CED, TAPPI), cp.	4.6	8.3	4.9	8.1	4.9	7.9

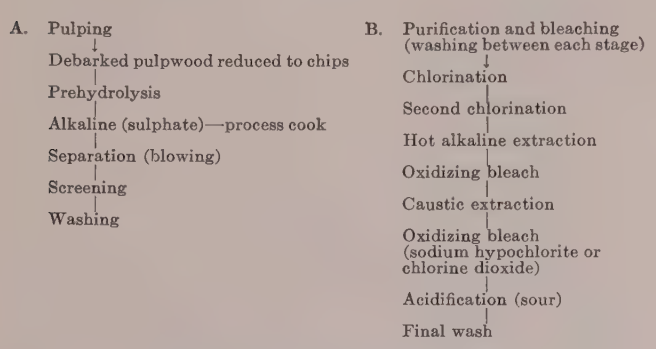

Fig. 1. Flowsheet of process tire cord grade woodpulp

ful source of cellulose was needed. Recognizing this, our organization, which processes both cotton linters and wood pulp, set out to provide from wood, a new chemical cellulose possessing the following qualities:

1. A high degree of chemical purity, as indicated by the alpha-cellulose test.
2. A minimum hemicellulose content, as indicated by the pentosan and resistant pentosan (in the alpha-cellulose portion) tests.
3. A minimum of material extractable by the common organic solvents (i.e., resins, resin acids, fatty acids, sterols).
4. A supermolecular structure as similar to that of purified second-cut cotton linters as possible.
5. A minimum of low D.P. material, in the pulp and in the aged alkali cellulose produced from it.
6. Good viscose processability (steeping, filtering, spinning).

The general process which was arrived at for the production of this improved wood pulp is outlined in Fig. 1. This process allows considerable flexibility of operation. By proper manipulation of process variables, almost any degree of pulp purity can be achieved with a good selection of viscosity. Table I illustrates a broad range of attainable chemical properties. The practical realization of a high purity wood pulp is illustrated by the chemical properties of normal plant production, listed in Table II. Tire cord grade is designated Type V-5. For comparison, the data for a typical wood pulp commercially available for the manufacture of tire cord yarn prior to this development, and those for tire cord grade cotton linters are included.

Table II. Chemical Properties of Tire Cord Cellulose

	Wood pulp (1950)	*Type V-5 Wood pulp (1958)*	*Cotton linters (1958)*
Alpha-cellulose, %	94.7	97.5	98.6
Beta-cellulose, %	2.4	1.5	1.2
Gamma-cellulose, %	3.2	1.0	0.2
Soda soluble, % (7.14% NaOH)	13.5	2.3	3.8
Pentosans, %	2.4	0.7	0.3
Resistant pentosans, %	Not available	0.5	0.2
Alcohol-benzene extractives, %	0.17	0.03	0.14
Viscosity (0.5%, CED, TAPPI), cp.	14	9.4	8.0
Ash, %	0.10	0.05	0.05
Calcium, p.p.m.	52	18	35
Iron, p.p.m.	10	4	9
Manganese, p.p.m.	0.16	0.10	0.20
Silica, p.p.m.	60	40	45

Referring to the quality objectives previously listed, the high degree of purity, implied in the first three items, has been substantially attained. The alpha cellulose test is high, the soda soluble portion is low, and material analyzing as pentosans has been greatly reduced, both in the whole pulp and in the alpha-cellulose portion (resistant pentosans). By one testing method it has been reported (*5*) that in the case of prehydrolyzed sulphate pulps from pine, fatigue resistance of tire cord increases with decreasing amounts of pentosans in the pulps.

Also, in general, the fatigue resistance of the cord was favored by low beta-cellulose content of the pulp, although here the initial average D.P. and the changes brought about by the alkali cellulose preparation and aging processes should be taken into account.

The objective of a low percentage of material extractable by the common organic solvents such as ether, or alcohol-benzene, was readily obtained, as had been expected from a sulphate pulping process.

The proportion of a cellulose pulp which is soluble in strong caustic is important to the viscose manufacturer. Table III lists the solubility in 10, 18, and 21.5% NaOH of ordinary textile grade wood pulp, the improved Type V-5 tire cord wood pulp, and cotton linters. Type V-5 is considerably improved over textile grade pulp, but is not yet equal to cotton linters. The 21.5% solubility figure has been cited as representative of the loss in yield between pulp and viscose yarn (*6*). Thus a 21.5% solubility of 1.3% may be related to a rayon yield of 98.7%.

Many viscose yarn producers favor testing which is more closely related to the actual manufacturing operation, and so place considerable importance on the low molecular weight fractions in the aged alkali cellulose. Obviously, a portion of the original pulp is soluble in the steeping caustic, but additional low

Table III. Solubility of Cellulose in Sodium Hydroxide Solution

	Textile grade wood pulp	*Type V-5 Tire cord grade wood pulp*	*Cotton linters*
Solubility[a] in			
10% NaOH (S-10)	6.3	2.7	2.0
18% NaOH (S-18)	4.4	1.6	0.4
21.5% NaOH (S-21.5)	4.0	1.3	0.3

[a] Method CCA 8:55 Analysis Committee of the Central Laboratory of the Cellulose Industry. The Swedish Association of Pulp and Paper Engineers. Also see TAPPI Tentative Standard T 235 m-58.

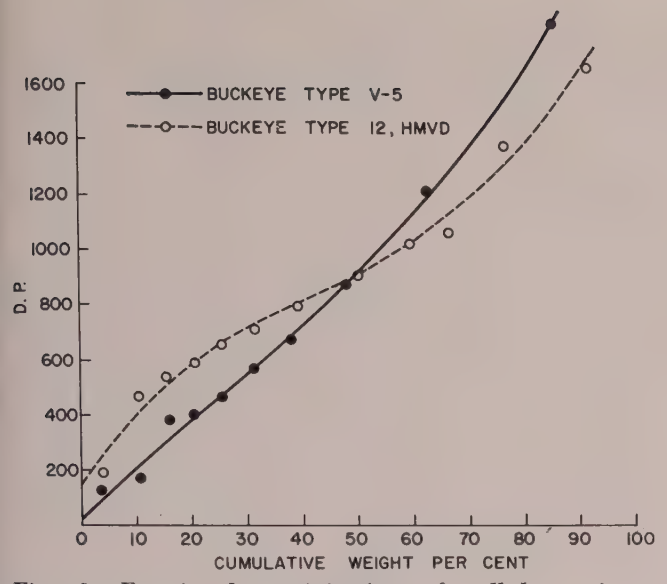

Fig. 2. Fractional precipitation of cellulose nitrate derivatives

molecular weight material may be produced by oxidative degradation during the aging step.

Table IV lists data for cotton linters and Type V-5 tire cord grade wood pulp showing the solubility in 10% NaOH solution of aged alkali cellulose at different degrees of aging represented by average D.P. levels. This caustic solution concentration has been shown to have maximum solubility for cellulose (*7*). In the second portion of this table, the alkali cellulose has been neutralized and the insoluble cellulose portion separated by washing and drying. The solubility of this recovered cellulose in 10% NaOH solution has also been determined.

Allowing for test variability, the solubility of alkali cellulose from cotton linters and from Type V-5 tire cord grade wood pulp is very nearly the same under normal tire yarn viscose processing conditions.

Frequent references (*3, 8–10*) have been made to molecular weight distribution of pulps, and the possible effect on tire cord properties. Nitrate fractional precipitation data for Type V-5 wood pulp and cotton linters are represented in Fig. 2. The point of inflection in the 800 to 1000 D.P. area indicates a relatively greater concentration of cellulose chain length in this range for cotton linters. Previous investigators (*3, 9*) have pointed out that if molecular weight distribution of the pulp is related to yarn and cord properties, it should be more clearly evident in the aged alkali cellulose. Figure 3 shows the cumulative weight percentages obtained by fractional precipitation of

Table IV. Effect of Aging on Caustic Solubility of Alkali Cellulose

	Solubility of aged alkali cellulose in 10% NaOH soln.			
Degree of aging-av. D.P.	700	600	500	400
Pressed and shredded alkali cellulose[a]				
Cotton linters, %	2.1	2.6	3.4	4.5
Type V-5 wood pulp, %	2.3	2.7	3.3	4.2
Cellulose recovered from alkali cellulose[b]				
Cotton linters, %	1.1	1.4	1.7	2.3
Type V-5 wood pulp, %	1.6	1.9	2.2	2.6

[a] Percentage based on sum of soluble and insoluble material.
[b] Percentage based on total recovered cellulose.

the nitrate derivatives of cotton linters and Type V-5 wood pulp which had been converted to alkali cellulose

Table V. X-Ray Diffraction Scatter for Purified Cellulose

Sample	*002 peak width at half maximum height (degrees 2θ)*
Cotton linters, tire cord grade	1.30
Type V-5, tire cord grade wood pulp	1.80
Sulphite viscose grade wood pulp	2.02

by ordinary viscose steeping and aged to the same average D.P. Differences in the molecular weight distribution between the two pulps have apparently been reduced by the alkali steeping and aging steps.

It has been postulated that viscose yarn and tire cord properties are related in some way to the supermolecular structure of the cellulosic starting material (*11, 16*). Reference has been made to a "seeding" effect and to a "memory" effect (*12, 13, 15*). The assumption here is that some molecular arrangements in the native cellulose are carried through the viscose solution stage and appear as focal points for crystallization of the yarn. This appears possible, since it is well known that viscoses contain varying amounts of residual pulp fragments (*17*).

L. R. Parks, in our laboratories, has investigated the supermolecular structure of different types of chemical celluloses (*18*). Particular attention has been paid to estimating the average dimensions of crystallites, and the uniformity of distribution of perfection of structure among the crystallites. X-ray techniques have been used effectively for this purpose. Data from this work are presented in Table V and Fig. 4. Table V shows a comparison of x-ray measurements in the 002 diffraction peak width, related (inversely) to the average dimensions of the crystallites. The measurement for Type V-5 tire cord grade wood pulp is typical of prehydrolyzed sulphate southern pine wood pulp in general. From the data, it is concluded that the crystallites in purified cotton linters pulp are considerably larger than those in wood pulps, and that, in crystallite size, Type V-5 tire cord grade pulp ranks between cotton linters and sulphite process wood pulps.

Figure 4 illustrates the regularity of the molecular structure, with the assumption that resistance to swelling in caustic is a function of order in the system. The change in cellulose II content with change in caustic concentration has been plotted against the caustic solution concentration contacting the cellulose.

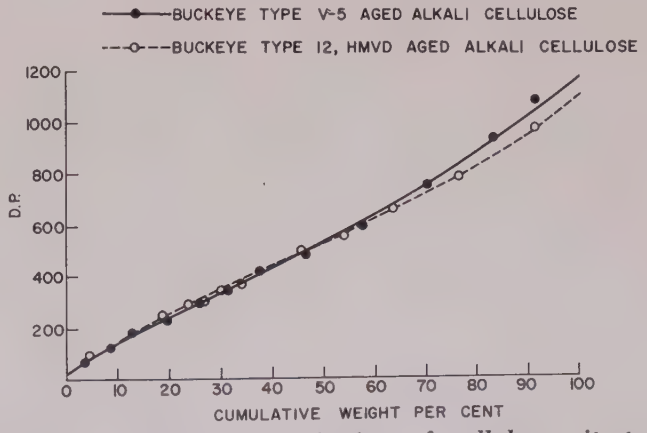

Fig. 3. Fractional precipitation of cellulose nitrate derivatives from aged alkali cellulose

Table VI. Viscose Tire Yarn Physical Properties

Pulp	Conditioned,[a] tenacity, g./den.	Conditioned,[a] elongation, %	Loop tenacity, g./den.	Loop elongation, %	Wet tenacity, g./den.	Wet elongation, %	Ratio: Wet to conditioned tenacity	Mechanical[b] constant
Cotton linters	4.47	14.0	3.47	8.2	3.10	32.2	0.694	158.2
V-5 Woodpulp	4.46	14.2	3.46	8.2	3.05	31.5	0.684	154.0

[a] Conditioned at 75°F., 60% R.H.
[b] The Mechanical Constant is numerically the product of 9 times the wet tenacity and the square root of the wet elongation. It is an attempt to express yarn quality in a single value.

The following conclusions have been drawn from the x-ray and lateral order distribution data.

1. The average size of crystallites increase in the order: Sulphite woodpulp, prehydrolyzed sulphate wood pulp, cotton linters.

2. Resistance to mercerization increases in the same order. This refers to the concentration of sodium hydroxide required to rearrange native cellulose crystal structure.

3. Prehydrolysis sulphate process wood pulp has less perfection of ordered regions than either cotton linters or sulphite wood pulp.

The last and most important set of characteristics for the user is concerned with the comparative performance of this new tire cord grade wood pulp and cotton linters in actual viscose preparation and spinning operation. These may be briefly summarized as follows:

Steeping properties are very similar to cotton linters. As is characteristic of cotton linters sheets, the highly purified wood pulp tends to float in the steeping press. This tendency can be partly offset by adjusting the rate of addition of the caustic steeping liquor.

Alkali cellulose aging properties are similar to cotton linters.

Xanthation behavior is also similar. With the same ripening conditions, the change in salt index, D.S., and xanthate sulphur to total sulphur ratio for the two celluloses are indistinguishable (*19*).

The viscose filterability level is somewhat superior to that of cotton linters. Filtration of viscose from Type V-5 wood pulp may be significantly improved by the addition of certain surface-active compounds to the pulp or to the alkali cellulose prior to xanthation. The same compounds have not been effective in improving the filterability of cotton linters viscoses.

Spinnability has been reported as entirely satisfactory with viscose from this highly purified wood pulp, and superior in this respect to cotton linters viscose.

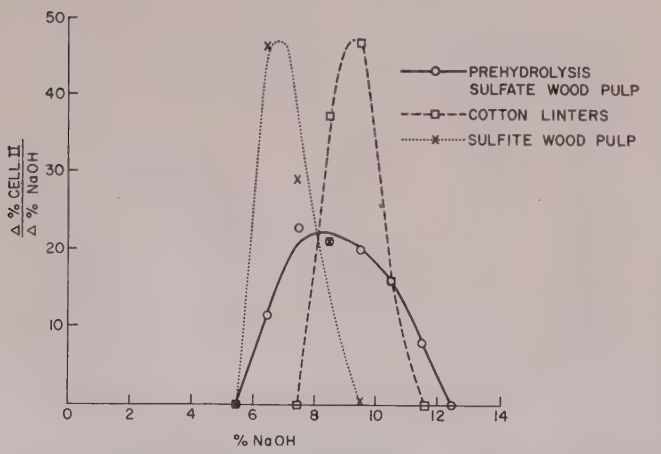

Fig. 4. Effect of caustic concentration on crystalline structure of cellulose

Data on tire yarn properties from small scale spinning of cotton linters and Type V-5 wood pulp viscoses are summarized ln Table VI. The figures are averages of over 20 spins with each material, and illustrate the result of a coordinated research and development program to provide a cellulosic material from wood suited to the most exacting requirement in the dissolving pulp industry.

Reports from manufacturers confirm that the new pulp is competitive with cotton linters in commercial super tire cord production.

SUMMARY

1. A dissolving grade chemical wood pulp has been developed specifically for the tire cord market, and successfully produced on a commercial scale. The process permits considerable flexibility in adjusting the chemical properties of the product to any desired combination.

2. This tire cord grade wood pulp has been shown to approach commercial purified second-cut cotton linters in chemical purity and supermolecular structure. Laboratory and plant evaluations indicate that a close similarity can be obtained in the final tire yarn and tire cord products.

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19. Unpublished data, Res. Dept., Tech. Div., The Buckeye Cellulose Corp.

RECEIVED July 8, 1959.

We gratefully acknowledge the assistance of A. M. Dowell, The Buckeye Cellulose Corp., in allowing the use of unpublished data in Figs. 2 and 3, and J. S. James, Jr., for data in Table VI.

ASSOCIATION NEWS AND EVENTS

National Conferences

Ninth Corrugated Containers Conference, Jung Hotel, New Orleans, La., Sept. 15–17, 1959.

Fourteenth Paper-Plastics Conference, Edgewater Beach Hotel, Chicago, Ill., Sept. 21–23, 1959.

Fourth Deinking Conference, Roger Smith Hotel, Holyoke, Mass., Oct. 8–9, 1959.

Fourteenth Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., Oct. 12–15, 1959.

Thirteenth Alkaline Pulping Conference, Robert Meyer Hotel, Jacksonville, Fla., Nov. 4–6, 1959.

Other 1959 Conferences

Sept. 13–18	Am. Chem. Society, Atlantic City, N. J.
Oct. 1–3	Third International Conference of the Technical Association of the Paper and Printing Industries of Hungary, Budapest, Hungary.
Oct. 13–15	American Society for Testing Materials, Third Pacific Area National Meeting, Joint TAPPI-ASTM Committee on Petroleum Wax, Sheraton-Palace Hotel, San Francisco, Calif.
Oct. 26–28	Packaging Institute, Statler Hotel, New York, N. Y.
Nov. 9–10	National Paperboard Assoc., New York, N. Y.
Dec. 1–2	North American Pulp, Paper, and Paperboard Industrial Waste Conference, Edgewater Beach Hotel, Chicago, Ill.

Local Section Meetings

Pacific: Sept. 23, 1959, Seattle, Wash., "Data Processing and Computors"; Nov. 17, 1959, West Linn, Ore., "Coating and Printing"; Jan. 12, 1960, Longview, Wash., "Engineering"; April 15, 1960, Everett, Wash., Shibley Award Meeting; May 5–7, 1960, Bellingham, Wash., or Harrison Hot Springs, Annual Meeting; September, 1960, Salem, Ore., "Modernization."

Golden Gate District (Pacific Section): Oct. 6, 1959, Pittsburg, Calif. Plant visit to Dow Chemical Co., Dec. 1, 1959, "Economics of the Paper Industry"; Jan. 26, 1960, "Manufacturing and Marketing of Molded Paper Products"; March 29, 1960, "Recent Advances in Materials Handling"; May 17, 1960, R. M. True Memorial Lecture.

Lake States:

Delaware Valley: Sept. 24, 1959, Downingtown Paper Co. and Downingtown Paper Box Co., Downingtown, Pa., plant tours. Oct. 22, 1959, Engineers Club, Philadelphia, Pa., "Felts"; Nov. 19, 1959, Engineers Club, Philadelphia, Pa., "Success in Safety"; Jan. 21, 1960, Engineers Club, Philadelphia, Pa., Operations Research Panel; Mar. 26, 1960, Benjamin Franklin Hotel, Philadelphia, Pa., 1960 Philadelphia Graphic Arts Conference; April 21, 1960, Engineers Club, Philadelphia, Pa., E. J. Albert Award Program; May 27, 1960, Beloit Eastern, Downingtown, Pa., tour and outing.

Kalamazoo Valley: Oct. 1, 1959, Harris Hotel, Kalamazoo, "New Fibers"; Nov. 12, 1959, Inman's Restaurant, Galesburg, "Personal Development"; Dec. 3, 1959, Inman's Restaurant, Galesburg, "Coating"; Jan. 21, 1960, Harris Hotel, Kalamazoo, Papermakers' Get-Together; March 17, 1960, Inman's Restaurant, Galesburg, "Graphic Arts"; April 21, 1960, Inman's Restaurant, Galesburg, "Stock Preparation"; May 12, 1960, Harris Hotel, Kalamazoo, Recognition Night, WMU Awards; June 21, 1960, Annual Golf Outing, Gull Lake Country Club.

New England: Oct. 2–3, 1959, Berkshire Inn, Great Barrington, Mass., Fall Meeting; Dec. 11, 1959, Past Chairmen's Night; April 8, 1960, Management Night; June 3–4, 1960, Chatham Bars Inn, Chatham, Mass., Spring Meeting.

New England (Eastern District): Armand's Restaurant, Route 9, Framingham, Mass.: Sept. 14, 1959; Nov. 9, 1959; Jan. 11, 1960; March 14, 1960.

Ohio: Sept. 15, 1959, Manchester Hotel, Middletown, Ohio, A joint meeting with the American Gas Association on the applications of gas in the paper industry. Speaker: Roy Whitney of The Institute of Paper Chemistry; Oct. 15, 1959, Manchester Hotel, "Food Additives", Speaker: A. A. Checchi; Nov. 10, 1959, Manchester Hotel, Middletown, Ohio, "Atomic Power Plant Development." This is a joint meeting with the Superintendents Association. Speaker: Ed Pandorf of C. G. & E. Dec. 10, 1959, Manchester Hotel, Middletown, Ohio, "Mechanics of Retention." Jan. 12, 1960, Manchester Hotel, Middletown, Ohio, "Clupak." Speaker: C. A. Shoudy. Feb. 11, 1960, Colony Restaurant, Swifton Center, Cincinnati, Ohio, plant tour through Formica, a division of American Cyanamid. March 15, 1960, Manchester Hotel, Middletown, Ohio, "Two-Phase Flow in a Wet Web." Speaker: Joe Parker, Beloit Iron Works. April 14, 1960, Miami University, Oxford, Ohio, a tour of the new Paper School. Subject: "High Polymers." Speaker: Herman Mark. May 12, 1960, Hartwell Country Club, Cincinnati, Ohio, Ladies' night.

Ohio (Indiana District): Marott Hotel, Indianapolis, Ind.: Sept. 15, 1959; Oct. 20, 1959, Visit to R. R. Donnelly plant, Crawfordsville, Ind.; Nov. 17, 1959; Dec. 15, 1959; Jan. 19, 1960; Feb. 16, 1960; March 15, 1960; April 19, 1960; May 17, 1960; June 21, 1960, Golf outing.

Empire State:

Empire State (Metropolitan District): 465 Lexington Ave., New York, N. Y.

Empire State (Northern District): Woodruff Hotel, Watertown, N. Y.

Empire State (Central District): University Club, 431 E. Fayette St., Syracuse, N. Y.

Empire State (Western District): Prospect House, Niagara Falls, N. Y.

Empire State (Eastern District): Queensbury Hotel, Glens Falls, N. Y.

Maine-New Hampshire: October 23–24, 1959, Lafayette Hotel, Portland, Me., Fall Meeting—"Stock Cleaning" June 17–18, 1960, Mountain View House, Whitefield, N. H., Annual Meeting.

Chicago: Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill.

Chicago (St. Louis District): Le Chateau Restaurant, 10405 Clayton Road, St. Louis, Mo., Sept. 24, 1959, Ladies' Night, guest speaker, Hon. J. T. Blair, Jr., Governor of Missouri.

Lake Erie: Sept. 17, 1959, Cleveland Engineering and Scientific Center, "Interpretation of the Latest F.D.A. Rulings on Food Additives and How They Will Affect the Packaging Industry." Speakers: George T. Daughters, Food and Drug Administration Chief, Detroit, Mich., and Robert J. Kelsey, Engineering Editor, *Modern Packaging.*

Oct. 15, 1959, Ohio Boxboard Co., Rittman, Ohio, plant tour; Nov. 19, 1959, Cleveland Engineering and Scientific Center, "Paper Requirements, Inks, Processing Advances and Problems of the Printing Industry"; Jan. 21, 1960, Cleveland Engineering and Scientific Center, Conference on Pulp and Paper Testing Equipment and Methods Including Laboratory Coating and Sheetmaking Techniques; Feb. 18, 1960, Colton Chemical Co., 6626 Union Ave., Cleveland, Ohio, plant tour; March 17, 1960, Cleveland Engineering and Scientific Center, "Off-Machine Coating with Emphasis on Waxing and Barrier Types and Base Paper Requirements."

Southeastern: Sept. 25–26, 1959, Francis Marion Hotel, Charleston, S. C., "Printing on Kraft Paper," by G. M. McGinnis, Union Bag-Camp Paper Corp.; "Quality Control in Corrugated Box Manufacture," by G. C. Lecky, F. J. Kress Box Co.; "Sweet Gum Sulphate and Neutral Sulphite Pulps for Linerboard," by D. J. Fahey and V. C. Sitterholm, U. S. Forest Products Laboratory; and visit to Charleston plant of the West Virginia Pulp & Paper Co.; Nov. 20–21, 1959, King and Prince Hotel, St. Simons Island, Ga.

Virginia-Carolina

Italian

Gulf Coast

Papermakers and Associates of Southern California

St. Louis District

The St. Louis District is anticipating one of the largest and finest meetings it has ever had. This meeting will be held the evening of Sept. 24, 1959, at Le Chateau Restaurant and will be Ladies' Night. The District is very fortunate in having as guest speaker the Governor of Missouri, the Honorable James T. Blair. His subject, as tentatively set up with the chairman, James R. Lyon, will cover the future of the paper industry in the State of Missouri.

Southeastern Section

The first meeting of the Southeastern Section of TAPPI in the 1959–60 year will be held in Charleston, S. C., on Sept. 25–26, 1959. The Friday session will be in the Francis Marion Hotel and will begin with a social hour, followed by dinner and the technical program. Registration will begin at 5:00 p.m. On Saturday morning the group will tour the Charleston mill of the West Virginia Pulp and Paper Co. The extensible paper units will be included in the tour. This will be the first opportunity for many of the Section members to see this latest development in the industry.

The technical meeting on Friday will consist of three papers:

"Printing on Kraft Paper," by G. M. McGinnis, Union Bag-Camp Paper Corp.

"Quality Control in Corrugated Box Manufacture," by G. C. Lecky, F. J. Kress Box Co.

"Sweet Gum Sulphate and Neutral Sulphite Pulps for Linerboard," by D. J. Fahey and V. C. Setterholm, U. S. Forest Products Laboratory.

The second meeting of the Section will be held at the King and Prince Hotel on St. Simons Island, Ga., on Nov. 20–21, 1959.

Kalamazoo Valley Section

The following committee chairman have been appointed for the Kalamazoo Valley Section for 1959–1960:

Program Chairman (ex-officio): Vice-Chairman, P. D. Graham, E. I. du Pont de Nemours and Co., Wilmington, Del.
Committee:
W. R. Noel, Kalamazoo Paper Co., Kalamazoo, Mich.
J. C. Tongren, Watervliet Paper Co., Watervliet, Mich.
D. A. Stanek, The Sutherland Paper Co., Kalamazoo, Mich.
G. F. Touse, Peninsular Paper Co., Ypsilanti, Mich.
Publicity Chairman: A. H. Hupp, The Watervliet Paper Co., Watervliet, Mich.
Arrangements Chairman: R. L. Jan, Western Michigan University, Kalamazoo, Mich.
Education Chairman: E. E. Stephenson, Jr., Sutherland Paper Co., Kalamazoo, Mich.

W. O. Kroeschell, *Chairman*

Student Membership

To encourage student membership the Association Bylaws have been amended to permit two classes of membership for students at North American universities, colleges, and technical institutes.

The original class of student membership is defined in Article III, Section 4 of the Association Constitution, which states "A student member shall be a bona-fide matriculated full time student and a candidate for a degree at a recognized school or shall be an individual under twenty-four years of age who is qualified to hold a subordinate position of a technical nature in the pulp and paper industry."

Annual dues for such members are ten dollars, and these members are entitled to all publications and privileges of membership except voting and holding office.

A second class of student membership has been established recently by the Executive Committee, and its features are described in Article IV of the Association Bylaws as follows:

"A student at a university, college, or technical institute may have the option of becoming a member of the Association under the following terms: 1. Payment of the initiation fee can be postponed until the student enters the industry and qualifies for associate membership. 2. Payment of an annual fee of four dollars, after he has applied by special forms of application which may be obtained from the educational institution. 3. Application for this special form of student membership must be reviewed each year; services to student members using this option will be limited to receipt of the association's magazine *Tappi*."

Before the start of their fall terms the pulp and paper schools in the United States will receive appropriate application forms for both classes of student membership. Readers who wish to have such application forms forwarded to other schools are asked to notify the Secretary-Treasurer of their wishes.

Annual Meeting Poll

In conjunction with the official ballot on the proposed amendment to the Constitution of the Technical Association of the Pulp and Paper Industry, an opinion poll on the location and timing of the TAPPI Annual Meeting was also conducted. Questionnaires were mailed to all TAPPI Active Members. The results of the opinion poll were as follows:

1. Is New York City satisfactory as our Annual Meeting site?
   Yes 785
   No 177
   No opinion 57
2. Would you prefer another city?
   Yes 152
   No 581
   No opinion 152
3. Would you prefer moving the Annual Meeting from city to city around the country every year?
   Yes 288
   No 619
   No opinion 100
4. Should TAPPI continue to schedule its Annual Meeting to coincide with that of the American Paper and Pulp Association?
   Yes 486
   No 215
   No opinion 329

In conjunction with question 2, 143 members specified a city other then New York as the Annual Meeting site. Chicago was mentioned in 75 of the replies with the remaining 68 answers split between 18 locations.

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Tappi Staff

Michael Kouris, a graduate of Trinity College in Dublin, Eire, with a M.Sc. degree from McGill University, Montreal, Que., has joined the *Tappi* Staff as Assistant Editor. Prior to coming to the Technical Association, Mr. Kouris was Supervisor of the Technical Information Department of the Visking Co., a Division of the Union Carbide Corp. in Chicago, Ill. He was previously with the Pulp and Paper Research Institute of Canada and Howard & Sons (Can.) Ltd., Cornwall, Ont.

Michael Kouris

With this addition, the Staff has been reorganized with R. G. Macdonald being named Editorial Director and Richard T. Bingham, Editor of *Tappi*.

Changes in Division Structure

The Industrial Division, one of the Association's nine technical divisions, has been dissolved, and its committees have been reassigned to three other divisions. This action was authorized by J. R. Lientz, TAPPI president, after it had received the unanimous approval of the Technical Operations Committee. According to W. H. Aiken, chairman of the Industrial Division, this reassignment of committees will place each in a division whose interests and objectives are closely related to those of the committee.

The Agricultural Fibers Committee has been assigned to the Pulp Manufacture Division, and the Training and Education Committee has been added to the Research and Development Division. Both the Water Committee and the Structural Fibrous Materials Committee have been placed in the Paper and Board Manufacture Division.

Simultaneously the name of the Paper Manufacture Division has been changed to the Paper and Board Manufacture Division to describe more accurately the scope of its activities.

Ninth Corrugated Containers Conference

"Engineering Advances and Demands of Modern Packaging" will be the theme of the fall conference of the Corrugated Containers Division of TAPPI to be held in the Jung Hotel, New Orleans, La., Sept. 15, 16, and 17, 1959. Committee meetings will be held on Tuesday, September 15. There will be two technical sessions on Wednesday, September 16, and plant tours on September 17 to Gaylord Container Division, Crown Zellerbach Corp., Bogalusa, La., or to Continental Can Co. in New Orleans.

The conference is open to all who are interested in corrugated containers production whether they are members of TAPPI or not. Hotel reservations may be made directly with the Jung Hotel.

R. L. Jenk, Mead Containers, Inc., Cincinnati, Ohio, chairman of the Corrugated Containers Division and J. H. Rooney, Continental Can Co., New Orleans, La., conference chairman, have developed an outstanding program.

The technical program on Wednesday, September 16, will open with a morning session on "Engineering Advances Contributing to the Reduction of Scrap." R. C. Hutcheson, Union Bag-Camp Paper Corp., Savannah, Ga., will be the moderator. After luncheon, the afternoon sessions theme is "What Is Required in Corrugated Board to Compete with the Demands of Modern Packaging." G. R. Wilmer, American Box Board Co., Grand Rapids, Mich., will be the moderator. This session will be followed by a social hour and a dinner in the Tulane Room at 7:00 p.m.

Featured, after dinner, will be Pinky Vidacovich, whose many years' experience in music and folklore around New Orleans, has enabled him to become an outstanding entertainer, specializing in original and quaint "Cajun" songs, tunes, and stories.

Conference Headquarters (Room No. 265)

TUESDAY, SEPT. 15, 1959

9:00 a.m. Steering Council (Room No. 9)

R. L. Jenk, *Chairman*

9:00 a.m. Container Testing Committee (Room No. 3)

M. J. Clark, *Chairman*

9:00 a.m.–10:30 a.m. Ladies' Coffee (Lounge No. 2)

2:00 p.m. Committee Meetings

Engineering (Room No. 3)
R. C. Hutcheson, *Chairman*

Industrial Engineering (Room No. 4)
W. C. Kline, *Chairman*

Process and Quality Control (Room No. 5)
K. R. Martin, *Chairman*

Production (Room No. 6)
R. W. Buttery, *Chairman*

Raw Materials (Room No. 7)
D. C. Shepard, Jr., *Chairman*

4:00 p.m.–9:00 p.m. Registration

WEDNESDAY, SEPT. 16, 1959

8:00 a.m.–3:00 p.m. Registration (Lounge No. 1)

9:00 a.m.–10:30 a.m. Ladies' Coffee (Lounge No. 2)

9:00 a.m.–12:00 **Noon Theme—"Engineering Advances Contributing to the Reduction of Scrap" (*Tulane Room*)**

R. C. Hutcheson, Union Bag-Camp Paper Corp., Savannah, Ga., *Moderator*

1. "Less Warp, Less Glue, More Speed," by D. B. Phillips, Longview Fibre Co., Longview, Wash.
2. "Attack Waste with Engineering," by C. B. Lawler, Union Bag-Camp Paper Corp., Savannah, Ga.
3. "Get More Press Hours with Rapi-Die Register," by D. Ellinger, Downing Box Co., Milwaukee, Wis.
4. "Automatic Slitter Alignment Savings," by P. Ziegler, Ft. Wayne Corrugated Paper Co. Div., St. Joe Paper Co., Ft. Wayne, Ind.

11:30 a.m. Cash Bar (Lounge No. 2)

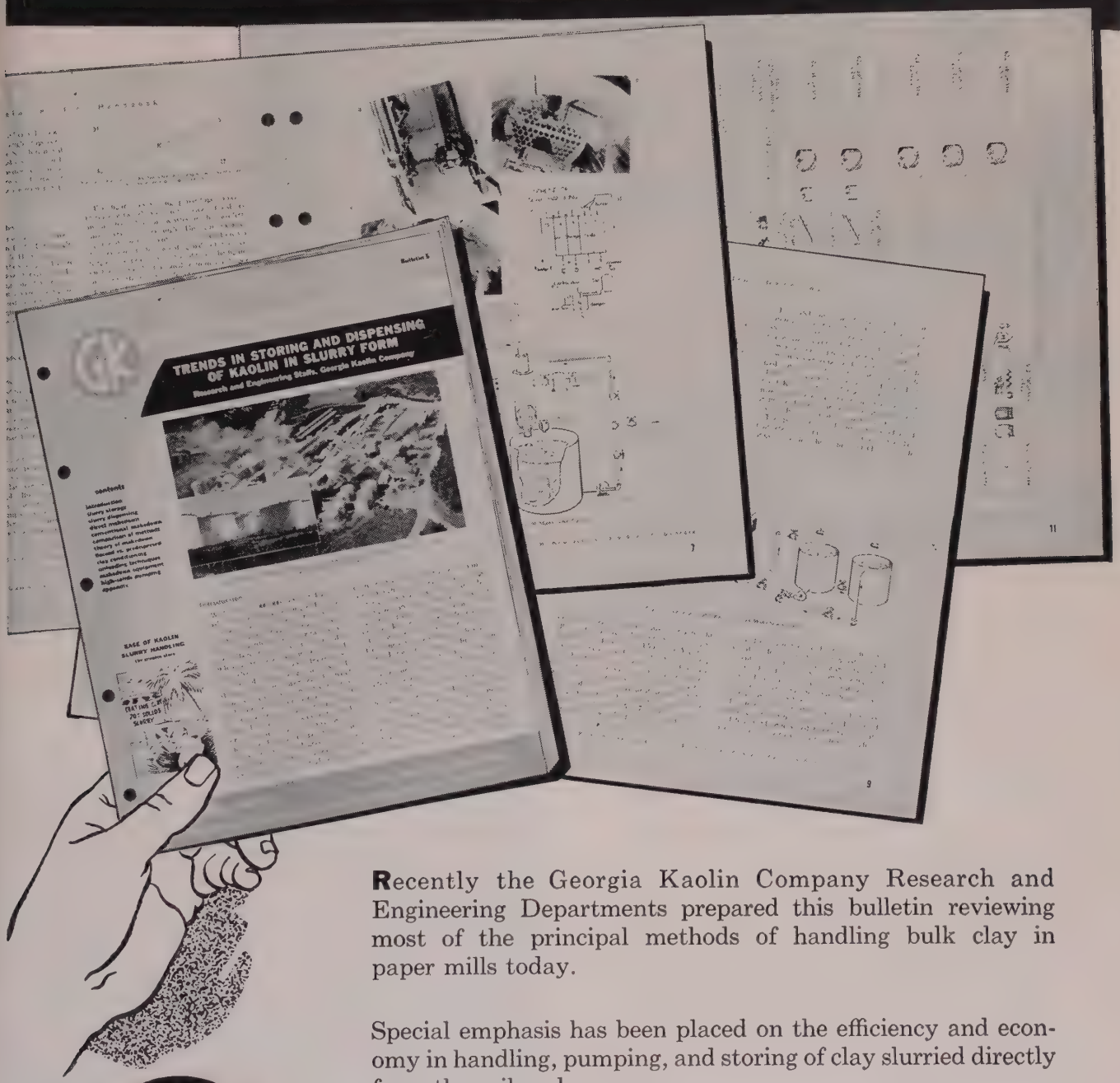
12:30 p.m. Luncheon (Tulane Room)

2:00 p.m.–5.00 p.m. **Theme—"What Is Required in Corrugated Board to Compete with the Demands of Modern Packaging?" (*Tulane Room*)**

G. R. Wilner, American Box Board Co., Grand Rapids, Mich., *Moderator*

1. "Semichemical Corrugating Medium," by J. Hamm, American Box Board Co., Filer City, Mich.
2. "Corrugating Variables and the Effect on Combined Board Characteristics," by R. C. McKee, The Institute of Paper Chemistry, Appleton, Wis.
3. "Resins and Coatings for Corrugated Board," by H. N. Johnston, Battelle Memorial Institute, Columbus, Ohio.

Modern Trends in STORING and HANDLING CLAYS


TRENDS IN STORING AND DISPENSING OF KAOLIN IN SLURRY FORM
Research and Engineering Staffs, Georgia Kaolin Company
contents

Recently the Georgia Kaolin Company Research and Engineering Departments prepared this bulletin reviewing most of the principal methods of handling bulk clay in paper mills today.

Special emphasis has been placed on the efficiency and economy in handling, pumping, and storing of clay slurried directly from the railroad car.

Paper mill engineering staffs studying the expansion or modernization of their bulk clay handling plants will find the charts, tables, and data contained in this bulletin very useful in planning their future systems.

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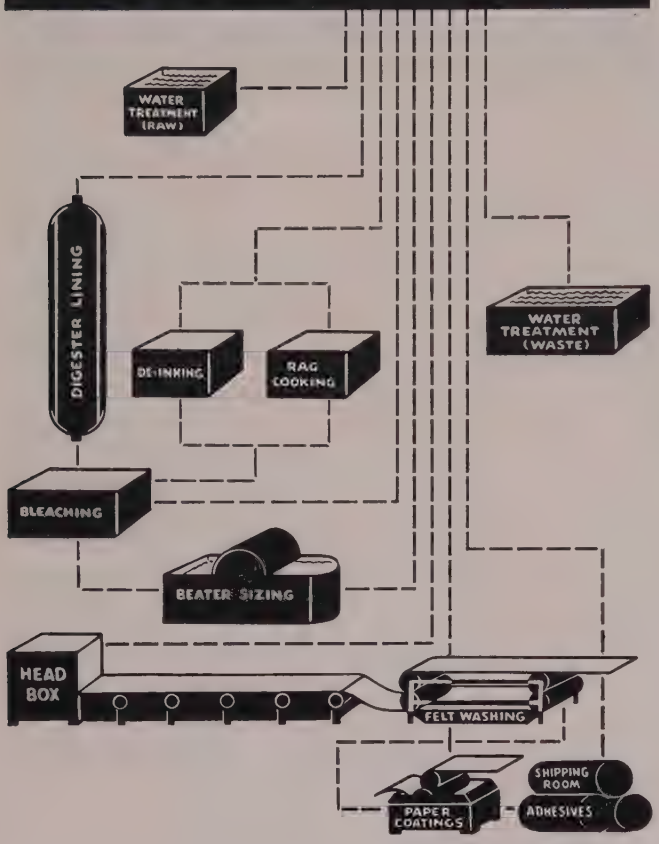

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#6-1 "PQ Soluble Silicates for the Pulp & Paper Industry"

#15-1 "Coating Paper Board with Sodium Silicate"

#52-19 "Treatment of Raw & Waste Waters with PQ Silicates"

#17-1 "PQ Soluble Silicates—Properties & Applications"

Check any of the above bulletins of interest to you.

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4. "Kraft Liners for Corrugated Board," by P. F. Hood, International Paper Co., Chicago, Ill.

5:30 p.m. ***Cash Bar (Lounge No. 2)***

6:00 p.m. ***Head Table Reception (Room No. 9)***

7:00 p.m. ***Banquet, featuring Pinky Vidacovich, Stories and Songs—"Cajun" Style***
R. L. Jenk, toastmaster (Tulane Room)

THURSDAY, SEPT. 17, 1959

9:00 a.m.-10:30 a.m. ***Ladies' Coffee (Lounge No. 2)***

*8:30 a.m.** ***Mill tour to Gaylord Container Div., Crown Zellerbach Corp., Bogalusa, La.***

10:00 a.m. ***Mill tour to Continental Can Co., New Orleans, La.***

Tenth Corrugated Containers Conference
Oct. 10–13, 1960
Royal York Hotel, Toronto, Ont.

* Note: This will be an all-day tour, with buses returning to the Jung Hotel about 6 :00 p.m.

Fourteenth Engineering Conference

Representatives attending the Fourteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry (TAPPI) on October 12–15 will be afforded a "bird's-eye" view into the fascinating operations of atomic power, steel making, and other steel specialty production during company-sponsored industrial tours in the metropolitan Pittsburgh area. Visitors also will have an opportunity to observe the manufacture from raw material to finished products of steels applicable to pulp and paper mill corrosion problems.

Westinghouse Research Center located in suburban Pittsburgh. Exhibits and demonstrations showing electroluminescence, the lighting of the future and thermoelectricity, an engineering triumph which undoubtedly will develop into major applications for tomorrow, are examples of highlights to be observed during the tour. Westinghouse Research Laboratories employ more than 800 people of which over 500 are professional scientists, laboratory technicians and assistants

This year's conference in the Penn-Sheraton Hotel represents the first time in TAPPI history that it is being held in Pittsburgh and ties in significantly with the city's observance of the 200th anniversary of its founding. This excellent opportunity, in addition to the industrial plant tours, will enable TAPPI members to see first hand the city's internationally-publicized renaissance program and industrial progress which has characterized the metropolitan area as the "Workshop of the World."

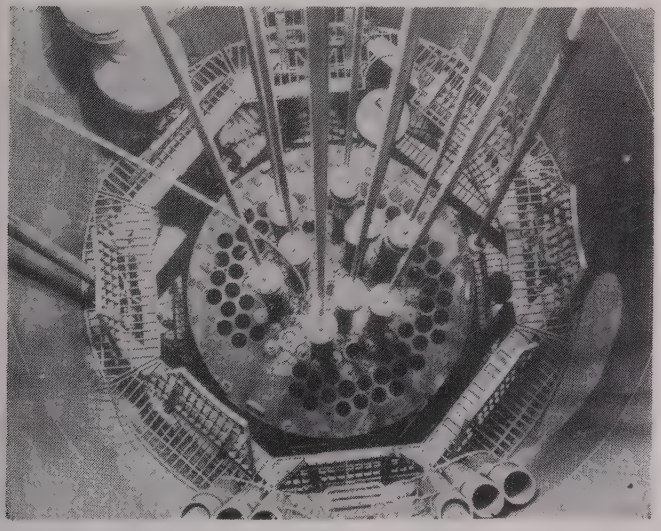
The local conference Arrangements Committee has announced that company-sponsored tours this year have been arranged with Westinghouse Electric Corp., the Jessop Steel Co., and the National Annealing Box Co., both of Washington, Pa., on October 15—the final day of the conference.

Westinghouse Offers Tours

Westinghouse Electric will provide tours to its suburban Pittsburgh Research Center and to Waltz Mills, the site of its test nuclear reactor. The facilities will allow TAPPI members to observe the operation of this plant featuring the handling of radioactive materials in hot cells. Detailed accounts of the reactors' purpose and capabilities, and plant operation including waste disposal and ventilation system, will be given representatives, who also will observe experimental test reactor and plexiglass reactor model demonstrations.

At the company's Research Center, whose laboratories are among the largest and finest in American industry doing basic and applied research in the physical sciences, groups will be oriented in the role of research and its scope of operation in the Westinghouse organization.

As part of the TAPPI program on Monday, October 12, Westinghouse will present a full-color film, "Atomic Power at Shippingport," which was produced for the Second International Conference on the Peaceful Uses of Atomic Energy, held at Geneva, Switzerland, in 1958. This film, along with other films from this country, represented the United States motion picture program which was designed to present the outstanding accomplishments in this nation in the field of atomic energy at the conference. "Atomic Power at Ship-



Facilities at Westinghouse's Waltz Mills, Pa., plant (near Pittsburgh) will allow visitors to see the operation of this plant featuring the handling of radioactive materials in hot cells. The Critical Experiment Station, shown above, is part of the Westinghouse test reactor facility and is used to evaluate the core design and to gather operating data for the testing reactor. CES is one of the two WTR critical facilities now available to industry for low-level irradiations, for test criticality, temperature coefficients and other core parameters

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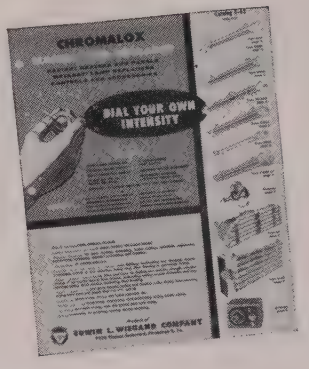

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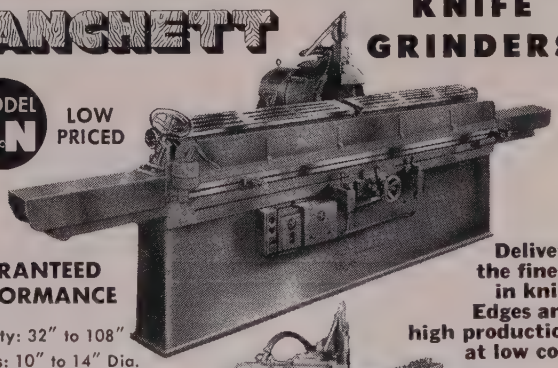

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West Coast: PORTLAND 1, OREGON

pingport" was shown at Palais des Nations by the United Nations, along with those films from the 61 countries participating in the conference.

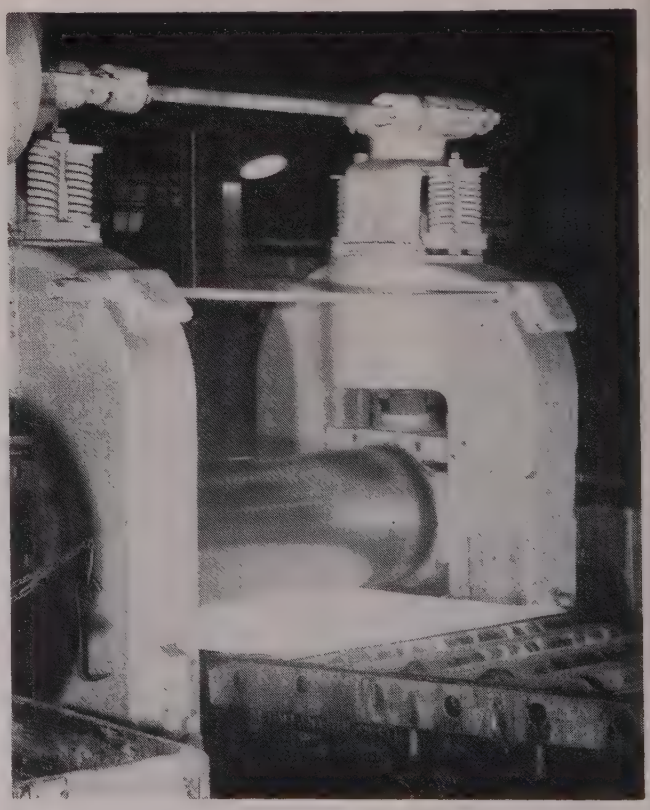
The film presents the purposes of the Shippingport, Pa., station, and describes some of the technical problems encountered in its development and how they were solved; plant operation, and progress coverage during its construction. Shippingport is the nation's first large-scale nuclear power plant designed and devoted exclusively to the generation of electricity for civilian use.

Jessop Mill Tour

TAPPI visitors touring the Jessop manufacturing operation will see one of the most highly-specialized, fully-integrated steel plants in the United States engaged in electric furnace melting, hot rolling, and finishing of stainless and stainless-clad steels. The company's melters carefully measure the necessary ingredients for making of stainless and alloy steels in Jessop's three electric furnaces.

One of the oldest steel companies in the world, Jessop was originally founded in Sheffield, England, in 1774. The company is an important supplier of specialty steels and its manufacturing facilities had contributed much to this country's booming industrial revolution during the 19th century.

The Jessop tour will enable members to observe how the Washington firm's steel making operations have served the pulp and paper industry in diversified ways for more than a century. During the tour they will see the rolling of stainless plate used in the pulp and paper industry in stainless and stainless-clad digesters, headboxes, and in the construction of stacks in waste liquor recovery plants; also, casting of stainless into valve bodies; the production of circular and band saw steels, and other high speed tool steels for manufacturing chipper knives, and the making of high carbon and high chrome steels used in producing paper knives.



Hot rolling stainless steel plate on 90-in. mill at Jessop Steel Co. plant in Washington, Pa., will be viewed in operation during the company-sponsored tour

TAPPI visitors to the Jessop Steel Co. plant in Washington, Pa., will have an opportunity to observe manufacture from raw material to finished products of steels applicable to pulp and paper mill corrosion problems. The Washington firm's operation is a fully-integrated specialty steel mill engaged in electric furnace melting, hot rolling and finishing of stainless and stainless-clad steels

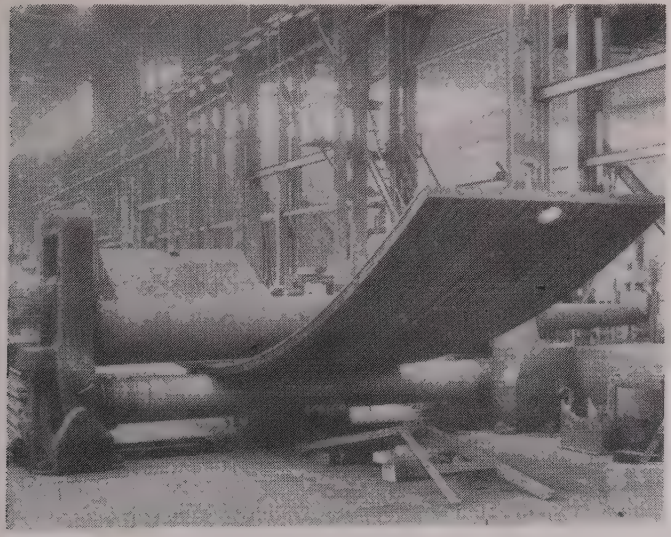
The company's flat ground specialities department where high quality steels are ground and polished to extremely accurate tolerances for use in gages, dies, verniers, and other exacting products also is included in the tour.

National Annealing Box Tour

At the Washington plant of the National Annealing Box Co., arrangements have been completed for TAPPI representatives to observe the firm's production operations which have served the interests of the pulp and paper industry for many years.

Of specific interest to the group will be the fabrication of stainless steel structures for use in paper mills, and how steel, stainless steel, and plates of other materials are formed, welded, stress relieved, and heat treated into such end products as pressure vessels, pipe, and accessories serving the country's varied industries since the firm was founded in 1895.

The company started early in the 20th Century to manufacture galvanizing kettles, which in later years led to the

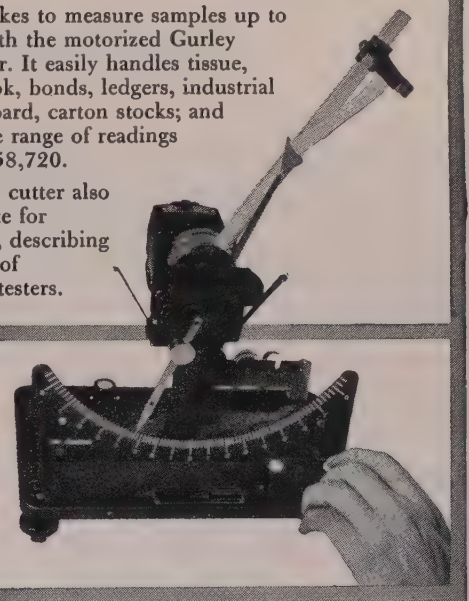


Cold forming 3-in. thick by 6-ft. wide plate at National Annealing Box Co. plant in Washington, Pa.

21 SECONDS *to Test Stiffness of Paper and Paper Board*

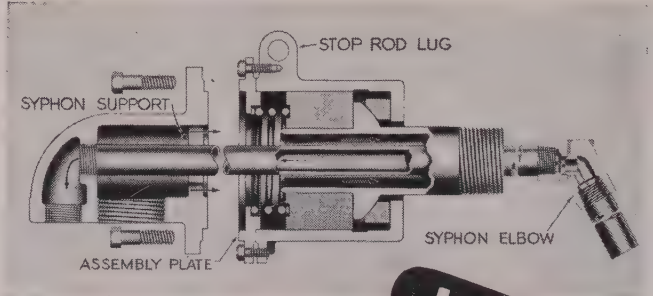
That's all it takes to measure samples up to 0.25" thick with the motorized Gurley Stiffness Tester. It easily handles tissue, newsprint, book, bonds, ledgers, industrial papers, cardboard, carton stocks; and permits a wide range of readings from 1 to 3,358,720.

Precision strip cutter also available. Write for Bulletin 1400, describing complete line of Gurley paper testers.



W. & L. E. Gurley
Station Plaza & Fulton Sts., Troy, N. Y.

Rotary Joint Headquarters ★ Johnson started the whole idea. Today's *complete* line includes sizes from ¼" to 8" . . . self-supported, pipe-supported, or rod-supported . . . for stationary or rotating syphon pipe . . . all operating speeds and pressures . . . for paper machines, calenders, corrugators, waxers, embossers, roofing machines, printing presses.

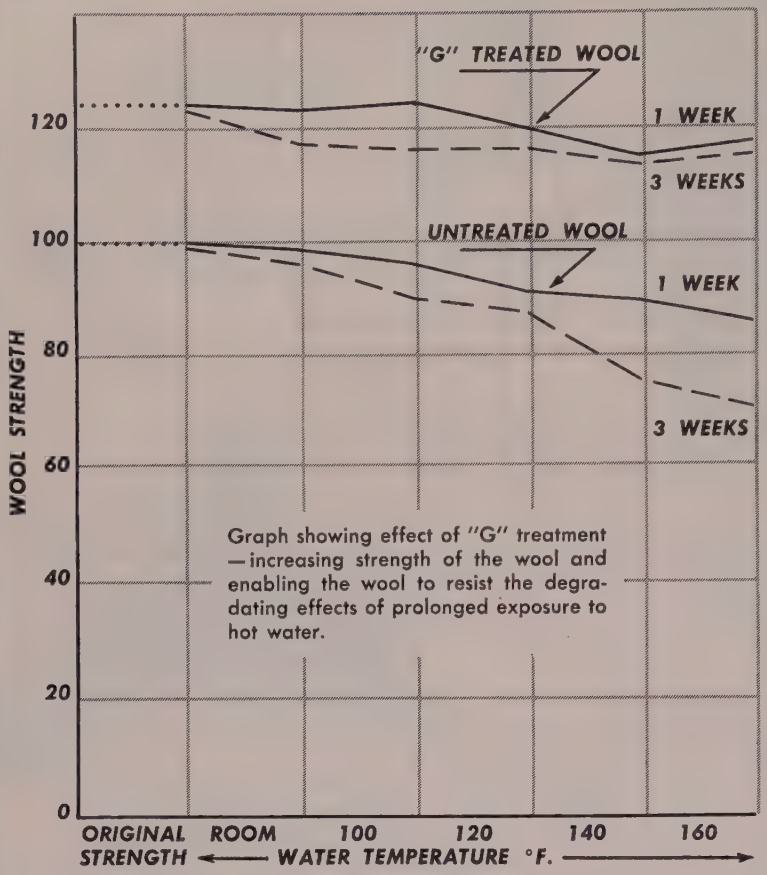


Type SDP shown. Hinged syphon elbow replaces unwieldy curved syphon pipes with two straight pipes. Newest Johnson development is the Quick Release nipple. Write for Bulletin S-3001.

Johnson Rotary Pressure Joints

First in the Paper Industry

THE JOHNSON CORPORATION
843 Wood St., Three Rivers, Michigan



THE EFFECT OF HOT WATER ON FELTS

New papermaking techniques often require new felt treatments.

In recent years board and roofing mills have been going more and more to higher furnish temperatures and placing more exacting demands on their felts. And hot presses are also hard on wool.

Mill tests show that a higher than normal furnish temperature causes felts to lose strength, which loss of strength sets the stage for felts to stretch and narrow, lose their resiliency, fill up sooner and, finally, to wear out faster.

Orr "G" Felt Developed and Proved in Service

To the already widely used Orr-Chem line of felts to resist acids and the An-bac line to counteract bacteria, Orr, some three years ago, added the "G" treated felt for use where hot water poses a felt problem. See the chart.

THE ORR FELT & BLANKET COMPANY
PIQUA, OHIO

natural development of fabricating medium-to-heavy carbon steel, stainless steel and high nickel pressure vessels and towers for the chemical and petroleum industries. In recent years, National Annealing has also become engaged in fabrications which involve high pressure nuclear equipment for atomic submarines, cryogenic tanks for the Air Force and Army, and related items.

Transportation and lunch will be provided for all TAPPI members planning to attend any of the company-sponsored tours. The tours will originate at the Penn-Sheraton Hotel starting at 9 a.m. on Thursday, October 15, and groups are expected to arrive at the hotel by 5 o'clock that afternoon.

Ladies' Program

Mrs. A. O. Caldwell, Chairman of the Ladies' Program Committee has announced that a feature event will be a visit to the University to see the Cathedral of Learning. This building, 42 stories high, is the heart and center of the University of Pittsburgh campus. The building houses the 19 Nationality Classrooms which will be an impressive high light of the town.

These beautiful rooms in the Cathedral of Learning are a very real and important part of education at the University of Pittsburgh. They are classrooms that in themselves are teachers. Their design and decoration are characteristic of many times and many peoples. They represent the best and noblest heritage of 18 of the nationality groups which have helped make Pittsburgh an industrial and cultural capital of the world.

These classrooms represent, too, the sacrifice and hope and understanding of hundreds of people—here and abroad. They say to students and teachers and visitors, "Here, people with their own hands, out of their own finest intelligence and deepest spiritual concepts, working together, have built into a great university fresh strength, and perennial hope that all men in the joy of striving after learning may reach the highest wisdom and the greatest good for all mankind."

The Ladies' Program will also include a visit to the Heinz Memorial Chapel and a brunch and style show at Joseph Horne's.

Members of the Ladies' Program Committee are Mesdames E. V. Anderson, R. R. Digby, M. H. Fisher, W, G. Gerstacker, H. G. Guy, C. D. Haxby. E. W. Hopper, O. J. Kellett, H. A. Latta, and C. Spangler.

Pulp Bleaching Conference

F. Kraft, Marathon Div., American Can Co., Menasha, Wis., chairman of TAPPI's Pulp Purification Committee, has announced the preliminary arrangements for the 1960 Pulp Bleaching Conference.

The conference will be held in the Edgewater Beach Hotel, Chicago, Ill., June 14, 15, and 16, 1960. R. J. Richter, Kimberly-Clark Co., Neenah, Wis., is technical program chairman.

Present plans include six technical sessions on principles, reaction mechanisms, kinetics, practices, and equipment of modern pulp bleaching. Plans also include a panel discussion by international visitors concerning current world-wide pulp bleaching practices.

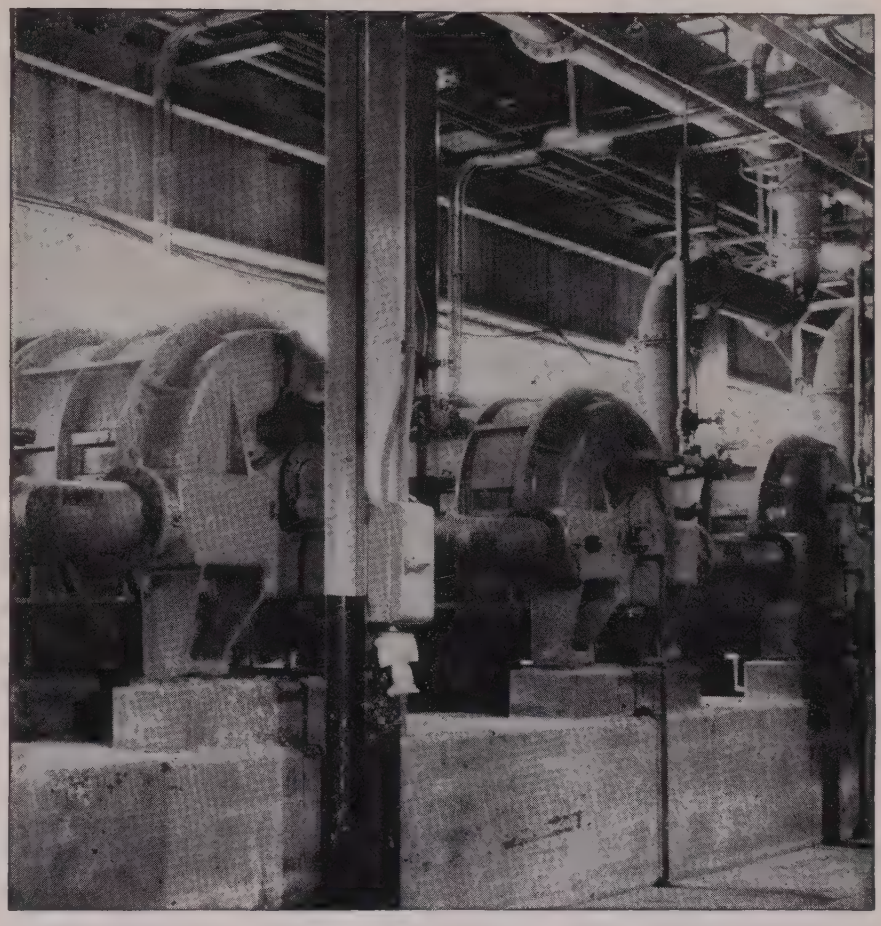
Pulp, Paper, and Paperboard Industrial Waste Conference

Plans are currently being formulated for a North American Pulp, Paper and Paperboard Industrial Waste Conference to be held at the Edgewater Beach Hotel, in Chicago, Ill., on Dec. 1 and 2, 1959. The conference is being jointly sponsored by the National Council for Stream Improvement, Inc., The Institute of Paper Chemistry, and the Sulphite Pulp Manufacturers' Research League.

A Program Committee consisting of N. L. Malcove and A. J. Wiley, technical director, Sulphite Pulp Manufacturers' Research League; Willis M. Van Horn, The Institute of Paper Chemistry; Arthur Van Vlissingen, Pulp and Paper Information Service; Russell L. Winget, executive secretary, and Harry W. Gehm, technical advisor, National Council for Stream Improvement, Inc. is preparing the program, details of which will be disclosed later.

The purpose of the conference is to accomplish an exchange of all pertinent basic data relating to pulp and paper industry waste disposal on an interregional basis. Experts in the field, whose names will be announced at a later date, will present papers. George E. Dyke, chairman, Board of Governors, National Council for Stream Improvement, Inc., will preside at the conference and the opening address will be delivered by John G. Strange, president, The Institute of Paper Chemistry.

What, actually, do Vacuum Pumps on paper machines handle?



Paper mill engineers know that it is actually a mixture of air and water vapor, but the custom of rating vacuum pumps in terms of air capacity alone causes this important fact to be frequently overlooked.

The presence of this water vapor causes a considerable reduction of the effective air handling capacity of any vacuum pump except the Nash. In the Nash Vacuum Pump the bulk of this water vapor is effectively condensed, due to the Nash operating principle. The air handling capacity of the Nash is therefore not reduced.

That is one of the reasons why Nash Vacuum Pumps are standard in over a thousand leading Paper Mills.

NASH ENGINEERING COMPANY

443 WILSON ROAD, SO. NORWALK, CONN.

The conference program will be devoted to the broad problems of stream sanitation and waste treatment and waste disposal applicable to all types of pulp and paper wastes. It is believed that a program of such nature will be of more universal industry interest than one dealing with individual wastes.

The conference will be subdivided into five general sessions as follows:

Session I—Waste Assimilative Capacity of Streams
Session II—Aquatic Biology
Session III—Solids Removal and Sludge Dewatering
Session IV—B.O.D. Reduction of Strong Spent Pulping Liquors
Session V—B.O.D. Reduction of Paper, Paperboard, and Weak Pulping Wastes

The Program Committee feels that, through the conference, first-hand information as to the nature of pulp and paper industry waste disposal problems, the basic science underlying the development of treatment and waste disposal methods, and a detailed summary of present treatment practices will be made available in comprehensive form to all interested.

The 2-day meeting will be open to all pulp, paper, and paperboard manufacturers in North America; representatives of state, interstate, and federal regulatory agencies; representatives of colleges, universities, and research institutions; the press, and all others interested in pulp and paper industry waste disposal problems. There will be no registration fees for those attending the conference for which invitations, including the complete program, the names of the speakers, and the titles of their papers, will be distributed in August.

Industrial Adhesives Institute

Engineering institutes in cooperation with the Glues and Gluing Division of Forest Products Research Society and the Forest Products Laboratory announces that its institute "Industrial Adhesives Applications" will take place on Thursday and Friday, Oct. 1 and 2, 1959, at the University of Wisconsin.

Companies using or considering using adhesives in the bonding of wood, metal, or plastic will find in this institute solutions to problems encountered in design and fabrication with adhesives, trouble shooting adhesive bonds, and future uses for adhesives to improve product quality or reduce product costs.

Outstanding speakers from industry and the Forest Products Laboratory will present the most progressive and important views on industrial adhesives applications.

The meeting will be held in the new Wisconsin Center Building on the main campus of the University of Wisconsin.

Further information may be obtained by writing Richard A. McCormick; Institute Coordinator; 4016 Stadium; The University of Wisconsin; Madison 6, Wis.

Industrial Packaging Institute

Engineering Institutes announces that its Second Annual Industrial Packaging Institute will take place on Thursday and Friday, Oct. 29 and 30, 1959, at the University of Wisconsin.

The initial packaging institute took place in September of last year and the interest shown by industry was most gratifying. Over a hundred people were in attendance from manufacturing plants not only in the Mid-West but ranging out to the East Coast and Southern States. The program at that time was more or less experimental, but sufficed to point the way for future packaging institutes to be presented by the University of Wisconsin.

The cost reduction aspects of packaging were touched on lightly during last year's program. This year more emphasis will be applied in this direction as well as exploring to a greater extent the relative obligation of top management and the packaging engineer toward a more efficient packaging program.

The increasing significance and impact of plastic materials in the packaging field will also receive attention.

The speakers and group leaders will be selected with great care. It is intended that these men will present to industry packaging thoughts and ideas revolving around the more important aspects of industrial packaging as they exist today.

The packaging institute this year, as last, will be held in the new Wisconsin Center Building on the main campus of the University of Wisconsin. This beautiful new building was created specifically for adult education programs and is admirably suited for an institute of this nature. The Institute of Industrial Packaging represents recognition on the part of the University of Wisconsin on the manifold problems confronting industry today.

Further information may be obtained by writing Richard A. McCormick; Institute Coordinator; 4016 Stadium; The University of Wisconsin; Madison 6, Wis.

Paper and Printing Conference (Hungary)

The Third International Conference of the Technical Association of the Paper and Printing Industries of Hungary will be held in Budapest on Oct. 1–3, 1959. According to Dr. George Vamos, director of the Research Institute of the Paper Industry, technical papers will be presented by the following men:

Messrs. Becker and Chadeyron, France
Mr. Borisek, Czechoslovakia
Messrs. Converse, Madsen, and Grant, England
Messrs. Giese and Reich, Germany
Mr. Simionescu, Rumania
Mr. Szwarcztajn, Poland
Messrs. Daut, Lengyel, and Juhasz, Hungary
Two papers from the Soviet-Union

In addition to the Hungarian representatives roughly 100 other delegates from Western and Eastern European countries have announced their plans to attend. Further information on this meeting can be obtained from Dr. George Vamos, Paper Research Institute, Budapest II, Hungary.

Statistics Symposium (Finland)

The Finnish Paper Engineers' Association is arranging a symposium (Statistical Methods in the Pulp and Paper Industry) in Helsinki on May 16–18, 1960, under the supervision of the EUCEPA-Organization ("Comité Européen de Liaison pour la Cellulose et le Papier"). EUCEPA was formed 3 years ago by the Western European Associations (or research centers or technical institutions in countries which have no local associations) in the pulp and paper field. The Executive Committee of EUCEPA consists of the presidents of the local associations. The purpose of EUCEPA is to coordinate the meetings of the local associations and to encourage the local associations to arrange inter-European meetings (symposiums). The purpose of these meetings is to bring together only specialists (50 to 150 in number) around some specific problem. So far there have been only two symposia (in 1958 in Darmstadt: Cellulose Analysis, in 1959 in Nordwijk, Holland: Straw Pulp) but several others are planned (printability of paper, paper testing, stream pollution, etc.).

Persons planning to present papers at the symposium are asked to submit the title of the paper before Aug. 15, 1959, an abstract before Oct. 15, 1959, and the complete paper before Jan. 15, 1960.

An organizing committee, with Professor Waldemar Jensen as chairman, has been appointed. The general secretary of the symposium is Nils J. Lindberg, to whom all correspondence should be addressed. Address: The Finnish Paper Mills' Association, Helsinki, Finland.

1959–60 Local Sections Officers

Pacific Section (Chartered in 1929)

Chairman: Norval Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash.
Vice-Chairman: Porter T. Dickie, Crown Zellerbach Corp., West Linn, Ore.
Secretary-Treasurer: Robert H. Smythe, Ray Smythe Co., Portland, Ore.
Executive Committee: Alfred Graef, Weyerhaeuser Timber Co., Everett, Wash.; Paul J. Frost, Crown Zellerbach Corp., Research Div., Camas, Wash.; B. T. Briggs, Rayonier Inc., Olympic Research Div., Shelton, Wash.; Lyle Gordon, Scott Paper Co., Everett, Wash.; Douglas Armstrong, R. T. Vanderbilt Co., Portland, Ore.; Paul S. Billington, Weyerhaeuser Timber Co., Longview, Wash.

Golden Gate District (Pacific Section) (Established in 1957)

Chairman: John Hartsock, International Paper Co., Container Div., San Jose, Calif.
Vice-Chairman: H. W. Theller, Crown Zellerbach Corp., San Francisco, Calif.
Secretary-Treasurer: H. A. Harvey, Penick & Ford Ltd., Inc., Cedar Rapids, Ia.
Recording Secretary: Walter Brandt, General Dyestuff Div., General Aniline & Film Corp., San Francisco, Calif.
Executive Committee: D. F. Church, Crown Zellerbach Corp., Antioch, Calif.; L. G. Maclise, Dow Chemical Co., San Francisco, Calif.; H. L. Rammer, Fibreboard Paper Products Corp., San Francisco, Calif.

Lake States Section (Chartered in 1930)

Chairman: Robert Leaf, Jr., Shawano Paper Mills, Shawano, Wis.
Vice-Chairman: William R. Nelson, Green Bay Paper & Pulp Co., Green Bay, Wis.
Secretary: Willard Stinger, Marathon Division, American Can Co., Neenah, Wis.
Treasurer: John F. Whalen, Combined Locks Paper Co., Combined Locks, Wis.
Executive Committee: Ray S. Bender, Appleton Machine Company, Appleton, Wis.; Sherwood G. Holt, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.; Francis T. Ratliff, Rhinelander Paper Co., Rhinelander, Wis.; John W. Swanson, The Institute of Paper Chemistry, Appleton, Wis.

Delaware Valley Section (Chartered in 1931)

Chairman: George K. Boger, Jr., Amalgamated Chemical Co., Philadelphia, Pa.
First Vice-Chairman: Alfred L. Saindon, Jr., Curtis Paper Co., Newark, Del.
Second Vice-Chairman: C. A. Wynn, Container Corp. of America, Philadelphia, Pa.
Secretary: Thomas P. Czepiel, Scott Paper Co., Chester, Pa.
Treasurer: Henry Smaine, P. H. Glatfelter Co., York, Pa.

R. L. Leaf, Jr., Shawano Paper Mills; Chairman, Lake States Section

G. K. Boger, Jr., Amalgamated Chemical Co.; Chairman, Delaware Valley Section

Executive Committee: Officers and D. C. Kane, Hercules Powder Co., Wilmington, Del., and C. F. Ackerman, Union Mills Paper Mfg. Co., New Hope, Pa.

Kalamazoo Valley Section (Chartered in 1931)

Chairman: William O. Kroeschell, The Michigan Carton Co., Battle Creek, Mich.
Vice-Chairman: P. Dean Graham, E. I. du Pont de Nemours & Co., Wilmington, Del.
Secretary: Wilbur L. Kite, The Lee Paper Co., Vicksburg, Mich.
Treasurer: J. D. Chatterdon, The KVP Co., Parchment, Mich.
Executive Committee: Officers and R. M. Levy, Allied Paper Corp., Kalamazoo, Mich.; John C. Tongren, The Watervliet Paper Co., Watervliet, Mich.; Wilbur R. Noel, The Kalamazoo Paper Co., Kalamazoo, Mich.; Howard H. Parker, Hercules Powder Co., Kalamazoo, Mich.; Robert W. Hagemeyer, The Wyandotte Chemicals Co., Wyandotte, Mich.; Gordon Gill, Penick & Ford Ltd., Inc., Cedar Rapids, Ia.; Raymond S. Janes, Western Michigan University, Kalamazoo, Mich.; C. E. Mueller, Lockport Felt Co., Newfane, N. Y.; Glen F. Touse, The Peninsular Paper Co., Ypsilanti, Mich.; E. E. Stephenson, Jr., Sutherland Paper Co., Kalamazoo, Mich.

New England Section (Chartered in 1933)

Chairman: John Lewis, Lowell Technological Institute, Lowell, Mass.
Vice-Chairman: Joseph F. Theriault, Robt. Gair Div., Continental Can Co., Uncasville, Conn.
Treasurer: Alexander E. Hutton, Jr., Fitchburg Paper Co., Fitchburg, Mass.
Secretary: Peter J. Fitzpatrick, American Cyanamid Co., Boston, Mass.
Executive Committee: Charles I. Horton, Philadelphia Felt Co., Norwalk, Conn.; Joseph A. Theriault, Continental Can Co.,

Vanceometer
Absorption Tester

At the machine—in the laboratory—Vanceometer photoelectric absorption test takes less than 1 minute to run.

Board mills and Paper mills use the Vanceometer test for quality control to meet customers' printability requirements.

Converters, cartonmakers, and printers have adopted the Vanceometer test as a standard specification to help assure them of receiving stock with desired printability and absorption characteristics.

Suppliers to the Paper & Paperboard Industry use the "Vanceometer," to maintain quality control.

Use of the Vanceometer will enable you to

- **Obtain a numerical rating of printability**
- **Obtain a numerical rating of absorption into board and paper**
- **Measure the receptivity of board and paper for sizing, coatings, adhesives, inks, etc.**
- **Test plain or colored stock.**

In today's competitive market, it is essential that strict quality control be maintained. The Vanceometer pays for itself in less than one week of operation. Requires no maintenance, is simple and easy to operate. Used by leading mills, converters and printers throughout the U. S., Canada, Mexico and Europe.

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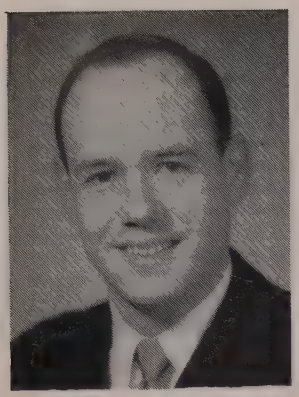


W. O. Kroeschell, The Michigan Carton Co.; Chairman, Kalamazoo Valley Section

C. E. Eberly, Paper Art Co.; Chairman, Indiana District, Ohio Section

Uncasville, Conn.; Phillip L. Slayton, Monsanto Chemical Co., Boston, Mass.; Richard Talbot, R. T. Vanderbilt Co., Stamford, Conn.; David Habib, Technifax Co., Holyoke, Mass.; E. Whitman Strecker, Esleeck Mfg. Co., Turners Falls, Mass.; A. E. Hutton, Jr., Fitchburg Paper Co., Fitchburg, Mass.; J. D. G. Thomson, Northeastern Paper Sales, Inc., Longmeadow, Mass.; E. J. Ferrell, Crocker, Burbank & Co., Assn., Fitchburg, Mass. Miss Helen U. Kiely was unanimously elected to the Executive Committee as an Honorary Member.

Eastern District (New England Section) (Established in 1957)

Chairman: Roger N. Wiewel, Pulp Div., Weyerhaeuser Timber Co., Clinton, Mass.
Vice-Chairman: John W. Wendell, Jr., Tileston & Hollingsworth Co., Hyde Park, Mass.
Secretary: Albert C. Lamoureux, Dennison Mfg. Co., Framingham, Mass.
Treasurer: Philip Slayton, Monsanto Chemical Co., Boston, Mass.
Executive Committee: Officers and Thomas Allan, Virginia Smelting Co., East Walpole, Mass.; John Frankevicz, Oxford Paper Co., Lawrence, Mass.; Thomas J. Sargent, Nashua Corp., Nashua, N. H.; Charles H. Horch, Mead Corp., Leominster, Mass.; and E. Whitman Strecker, Esleek Mfg. Co., Turner's Falls, Mass.

Ohio Section (Chartered in 1935)

Chairman: Virgil E. Perry, Harding-Jones Paper Co., Middletown, Ohio.
Vice-Chairman: Charles S. Sweitzer, Diamond Gardner Corp., Middletown, Ohio.
Treasurer: Adam Suchecki, National Starch Products, Dayton, Ohio.
Recording Secretary: George Martin, Champion Paper & Fibre Co., Hamilton, Ohio.
Corresponding Secretary: Stanley W. Trosset, Diamond Gardner Corp., Middletown, Ohio.
Program Chairman: Burton P. Bailey, Jr., The Mead Corp., Chillicothe, Ohio.
Executive Committee: Malcolm G. Lyon, Champion Paper & Fibre Co., Hamilton, Ohio; Ellsworth H. Shriver, The Mead Corp., Chillicothe, Ohio; William H. Aiken, Diamond-Gardner Corp., Middletown, Ohio; George B. Gregg, Cincinnati Gas & Electric Co., Cincinnati, Ohio; E. William Petrich, Howard Paper Co., Dayton, Ohio; Frank Cessna, Sorg Paper Co., Middletown, Ohio.

Indiana District (Ohio Section) (Established in 1957)

Chairman: Charles E. Eberly, Paper Art Co., Inc., Indianapolis, Ind.
Vice-Chairman (Programming): W. Doyle Boggess, The Beveridge Paper Co., Indianapolis, Ind.
Vice-Chairman (Membership): John S. Sullivan, Monsanto Chemical Co., Indianapolis, Ind.
Secretary: Cushing B. Roth, Morningstar-Paisley Inc., Indianapolis, Ind.
Treasurer: Thomas F. Sullivan, Hartford City Paper Co., Hartford City, Ind.
Executive Committee: S. R. Sutphin, The Beveridge Paper Co., Indianapolis, Ind.; W. B. Lincoln, Jr., Inland Container Corp., Indianapolis, Ind.; M. L. Johnson, Container Corp., of America, Wabash, Ind.; H. O. Ware, The Beveridge Paper Co., Indianapolis, Ind.

Empire State Section (Chartered in 1938)

Chairman: F. W. O'Neil, College of Forestry, State Univ. of New York, Syracuse, N. Y.
First Vice-Chairman: J. C. Rice, Lowe Paper Co., Ridgefield, N. J.
Second Vice-Chairman: J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.
Third Vice-Chairman: E. H. Johnson, Stevens & Thompson Paper Co., Greenwich, N. Y.
Secretary: C. B. Blanchard, Buffalo Rubber & Supply, Inc., Buffalo, N. Y.
Treasurer: J. V. Wolff, Nopco Chemical Co., Glens Falls, N. Y.
Executive Committee: Officers and H. A. Spencer, Knowlton Bros., Watertown, N. Y.; W. R. Willets, Titanium Pigment Co., New York, N. Y.; G. K. Storin, International Graphite & Electrode Corp., Niagara Falls, N. Y.; G. G. Cole, Finch, Pruyn & Co., Inc., Glens Falls, N. Y.; Allen F. Holmes, Sealright-Oswego Falls Corp., Fulton, N. Y.; Edward F. Andrews, International Paper Co., Niagara Falls, N. Y.; Harold L. Peckham, Oxford Paper Co., New York, N. Y.; J. W. Morrow, Newton Falls Paper Co., Newton Falls, N. Y.; Russell C. Clark, Newton Falls Paper Co., Newton Falls, N. Y.; Paul Page, Imperial Color and Chemical Corp., Glens Falls, N. Y.

METROPOLITAN DISTRICT

Chairman: Harold L. Peckham, Oxford Paper Co., New York, N. Y.
Vice-Chairman: Francis R. Marchetti, Titanium Pigment Corp., New York, N. Y.
Secretary-Treasurer: Alfred M. Hartley, Jr., Nopco Chemical Co., Harrison, N. J.

NORTHERN DISTRICT

Chairman: Russell C. Clark, Newton Falls Paper Co., Newton Falls, N. Y.
Vice-Chairman: John L. Hudson, Crown Zellerbach Corp., Carthage, N. Y.
Secretary: Genevieve L. Reidy, St. Regis Paper Co., Deferiet, N. Y.
Treasurer: Robert Caswell, St. Regis Paper Co., Deferiet, N. Y.

CENTRAL DISTRICT

Chairman: Allen F. Holmes, Sealright-Oswego Falls Corp., Fulton, N. Y.
Vice-Chairman: Bert L. Channer, H. Waterbury & Sons, Oriskany, N. Y.
Secretary: Marie M. Martin, Sealright-Oswego Falls Corp., Fulton, N. Y.
Treasurer: Frank C. Smith, Huyck Felt Co., Syracuse, N. Y.

WESTERN DISTRICT

Chairman: Edward F. Andrews, International Paper Co., Niagara Falls, N. Y.
Vice-Chairman: Wm. Russell, Kimberly-Clark Corp., Niagara Falls, N. Y.
Secretary: Charles Kremers, Kimberly-Clark Corp., Niagara Falls, N. Y.
Treasurer: Harry Hulse, Upson Co., Lockport, N. Y.

EASTERN DISTRICT

Chairman: Paul Page, Imperial Color & Chemical Corp., Glens Falls, N. Y.

H. L. Peckham, Oxford Paper Co., Chairman, Metropolitan District, Empire State Section

R. L. Clark, Newton Falls Paper Co., Chairman, Northern District, Empire State Section

Vice-Chairman: Gordon Nicolson, West Virginia Pulp & Paper Co., Mechanicsville, N. Y.
Secretary: Vincent Pitts, American Cyanamid Co., New York, N. Y.
Treasurer: W. E. Montgomery, Finch, Pruyn Co., Inc., Glens Falls, N. Y.

Maine-New Hampshire Section (Chartered in 1940)

Chairman: Andrew J. Chase, University of Maine, Orono, Me.
Vice-Chairman: Charles T. Bockus, Eastern Corp., Bangor, Me.
Secretary-Treasurer: Harold E. Pratt, Pejepscot Paper Division, Brunswick, Me.
Executive Committee: Edward N. Poor, Hudson Pulp & Paper Co., Augusta, Me.; Roland J. Martin, Fraser Paper, Ltd., Madawaska, Me.; Bartlett Taylor, James A. Taylor & Son, Kearsarge, N. H.; J. F. Wright, National Aniline Div., New York, N. Y.; Paul Goodloe, Brown Co., Berlin, N. H.; Malcolm White, Oxford Paper Co., Rumford, Me.; Donald Bail, Great Northern Paper Co., Millinocket, Me.; Robert E. Perry, Hollingsworth & Whitney Div., Scott Paper Co., Waterville, Me.; Lawrence Adkins, Waterfalls Tissue Corp., Mechanic Falls, Me.; H. Whitney Osgood, S. D. Warren Co., Westbrook, Me.

Chicago Section (Chartered in 1943)

Chairman: Henry J. Klauke, Container Corp. of America, Chicago, Ill.
First Vice-Chairman: Carl M. Helm, American Cyanamid Co., Chicago, Ill.
Second Vice-Chairman: Melvin H. Meyer, Container Corp. of America, Chicago, Ill.
Third Vice-Chairman: William D. Kenny, Ace Carton Corp., Chicago, Ill.
Secretary: Paul Gronendyke, National Adhesives Div., National Starch Products Inc., Chicago, Ill.
Treasurer: Ray P. Caponi, Union Bag-Camp Paper Corp., Chicago, Ill.
Executive Committee: Officers and Edward C. Berg, Ace Carton Co., Chicago, Ill.; William D. Hall, Folding Paper Box Association of America, Chicago, Ill.; and Warren R. Price, Consultant, Skokie, Ill.; Melvin W. Snover, Hollingsworth & Vose Co., Chicago, Ill.

St. Louis District (Chicago Section) (Established in 1956)

Chairman: James R. Lyon, Alton Box Board Co., Alton, Ill.
Vice-Chairman: William J. Rice, Central States Paper & Bag Co., St. Louis, Mo.
Secretary: Henry W. Seibel, Gaylord Container Corp. Div., Crown Zellerbach Corp., St. Louis, Mo.
Treasurer: Michael J. Moriarity, Advanced Products Div., ACF Industries, St. Charles, Mo.
Executive Committee: Officers and R. M. Wilkinson, Alton Box Board Co., Alton, Ill.; J. F. Johnston, Union Starch & Refining Co., Granite City, Ill.; Don Santmyers, E. I. du Pont de Nemours, St. Louis, Mo.; J. H. Addison, H. B. Fuller Co., St. Louis, Mo.; E. P. Gillan, Union Starch & Refining Co., Granite City, Ill.; B. L. Scallet, Anheuser-Busch, Inc., St. Louis, Mo.; C. P. Olstad, Crown Zellerbach Corp., Western Waxide Div., St. Louis, Mo.; J. J. Koenig, Gaylord Container Corp. Div., Crown Zellerbach Corp., St. Louis, Mo.; J. C. Braznell, Champion Paper & Fibre Co., St. Louis, Mo.

H. J. Klanke, Container Corp. of America; Chairman, Chicago Section

J. R. Lyon, Alton Box Board Co.; Chairman, St. Louis District, Chicago Section

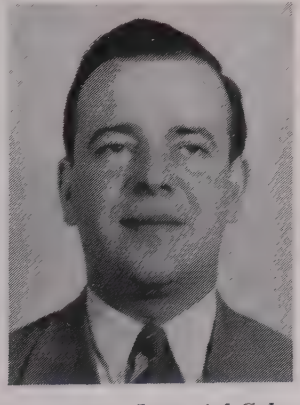
Lake Erie Section (Chartered in 1951)

Chairman: John C. Boynton, Fasson Products, Painesville, Ohio.
First Vice-Chairman: Bruce Doolittle, Chase Bag Co., Chagrin Falls, Ohio.
Second Vice-Chairman: David H. Payor, Scott Paper Co., Sandusky, Ohio.
Secretary: Francis J. Manning, Dairypak Butler, Inc., Cleveland, Ohio.
Treasurer: Robert C. Matthews, Chase Bag Co., Chagrin Falls, Ohio.
Executive Committee: Officers and Dennis E. Heindel, General Carton Co., Cleveland, Ohio; Tom McMonagle, Interchemical Corp., Cleveland, Ohio; Gardner Brown, Pennsylvania Industrial Chemical Corp., Cleveland, Ohio; Richard N. Campen, Colton Chemical Co., Cleveland, Ohio; John F. Richmond, Ace Electrotype Co., Cleveland, Ohio; David N. Cooper, Buckeye Ribbon & Carbon Co., Cleveland, Ohio.

Southeastern Section (Chartered in 1952)

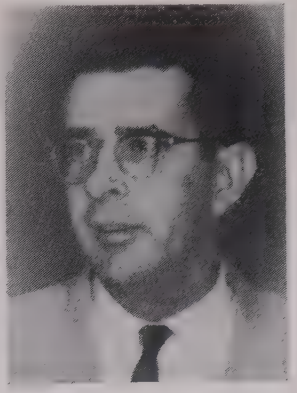
Chairman: R. R. Chase, Union Bag-Camp Paper Corp., Savannah, Ga.
Vice-Chairman: R. A. Flick, Brunswick Pulp & Paper Co., Brunswick, Ga.
Recording Secretary: M. O. Benjamin, Owens-Illinois Glass Co., Jacksonville, Fla.
Corresponding Secretary: R. E. Millar, Union Bag-Camp Paper Corp., Savannah, Ga.
Treasurer: J. Smith, Southern Paperboard Corp., Port Wentworth, Ga.
Executive Committee: Officers and B. M. Reaves, Sonoco Products Co., Hartsville, S. C.; D. O. Adams, West Virginia Pulp and Paper Co., Charleston, S. C.; W. C. Chapman, Union Bag-Camp Paper Corp., Franklin, Va.; J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga.

A. F. Holmes Seabright-Oswego Falls Corp., Chairman, Central District, Empire State Section



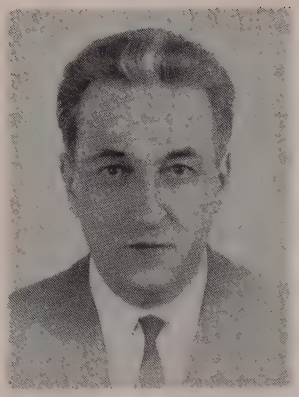
P. L. Page, Imperial Color & Chemical Corp.; Chairman Eastern District, Empire State Section

J. C. Boynton, Fasson Products; Chairman, Lake Erie Section



R. R. Chase, Union Bag-Camp Paper Corp.; Chairman, Southeastern Section

R. F. Miller, Continental Can Co., Chairman, Virginia-Carolina Section



Piero Bersano, Cartiere Burgo; Chairman, Italian Section

***Virginia-Carolina Section* (*Chartered in 1957*)**

Chairman: Ross F. Miller, Continental Can Co., Hopewell, Va.
Vice-Chairman: Roy Traver, Union Bag-Camp Paper Corp., Franklin, Va.
Secretary-Treasurer: Garland Edmonds, Chesapeake Corp. of Virginia, West Point, Va.
Executive Committee: George Renninger, American Viscose Co., Fredericksburg, Va.; Edward Dozier, The Chesapeake Corp. of Va., West Point, Va.; Kenneth Running, Halifax Paper Co., Roanoke Rapids, N. C.; William Chapman, Union Bag-Camp Paper Corp., Franklin, Va.; Edward Schultz, West Virginia Pulp & Paper Co., Covington, Va.; Sterling Bailey, North Carolina Pulp & Paper Co., Plymouth, N. C.; Robert Hobbs, National Bureau of Standards, Washington, D. C.; W. A. Green, Jr., Manchester Board & Paper Co., Richmond, Va.; Clark Snook, Nopco Chemical Co., Charlottesville, Va.; Robert Simmons, U. S. Government Printing Office, Washington, D. C.; C. E. Libby, North Carolina State College, Raleigh, N. C.; J. L. Baker, Albemarle Paper Mfg. Co., Richmond, Va.

***Gulf Coast Section* (*Chartered in 1959*)**

Chairman: Wm. Elsevier, International Paper Co., Mobile, Ala.
Vice-Chairman: A. L. Hargraves, St. Joe Paper Co., Port St. Joe, Fla.
Secretary: N. E. LeMaistre, Container Corp. of America, Brewton, Ala.
Treasurer: M. T. Still, St. Regis Paper Co., Pensacola, Fla.
Executive Committee: R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala.; I. S. Walker, International Paper Co., Mobile, Ala.; J. E. Doyle, St. Regis Paper Corp., Pensacola, Fla.

***Italian Section* (*Sezione Italiana*) (*Chartered in 1959*)**

Chairman: Piero Bersano, Cartiere Burgo, Torino.
Vice-Chairman: Pietro Ghisoni, Cartiere Vita Mayer, Milano.
Vice-Chairman: Giuseppe Nilla, Cartiere Villa, Milano.
Secretary-Treasurer: Alessandro Restagno, Cartiere Burgo, Torino.
Directors: Giacomo Bosso, Cartiere Bosso, Torino; Alberto Marsoni, Cartiere Marsoni, Venezia; Corrado Nodari, Cartiere Prealpine, Milano.
Executive Committee: Edoardo Cirla, Cartiere Binda, Milano; Carlo Gregotti, Cartiere di Verona, Milano; Carlo Ruspa, Cartiere Burgo, Torino.

A.I.E.E. Pulp and Paper Conference

The Fifth Annual Conference on Electrical Engineering as applied to the Pulp and Paper Industry was held during June 18–19, in the Louis Oakes Room of the Library Building on the extensive campus of the University of Maine. This conference was attended by 150 ranking electrical engineers from the mills and allied industries. Attendance was from wide spread areas and included mill electrical engineers from as far away as Florida, Minnesota, and Texas.

The two-day conference was highlighted by an interesting program of technical papers and timely addresses.

Addresses of welcome were given by Prof. W. J. Creamer, of the School of Electrical Engineering, and Prof. L. C. Jenness, head, Chemical Engineering Dept., both of the University of Maine.

AIEE Pulp & Paper Subcommittee: front row—S. Anderson, West Virginia Pulp & Paper Co.; S. J. Cambell, Westinghouse Electric Co.; J. S. Kirkland, Rome Kraft; C. H. Hudson, General Electric Co.; C. L. Eletson, Alton Box Board; S. A. Bobe, Westinghouse; D. C. Pier, Beloit Iron Works; T. A. Likos, Westinghouse. Second row—M. L. Perkins, Fraser Paper Co.; R. J. Farrell, Reliance Electric; J. B. Grady, Oxford Paper; W. H. Buford, Continental Can; E. H. Overby, Union Bag-Camp Paper Corp.; C. B. White, Allis-Chalmers; G. E. Shaad, General Electric; J. M. Yarbrough, Mead Corp.; M. J. Osborne, Bowaters Southern Corp.

J. L. Ober, president, University of Maine Pulp and Paper Foundation, gave a very enlightening luncheon address at Stoddard Hall, June 18. Mr. Ober explained how the University of Maine prepared young aspirants for high level positions in the pulp and paper field, by offering special selected courses beyond a B.S. degree, which led to a certificate denoting administrative ability in this field. Mr. Ober further stated that this practice was very enthusiastically assisted by the foundation consisting of many mills and allied organizations, and directed by top level executives from these organizations.

John Gould, well-known author and lecturer, addressed the banquet held the evening of June 18, at the Penobscot Valley Country Club. Mr. Gould very fluently pointed to the contributions to our early American history by the State of Maine.

High Voltage Motor Insulation Panel; front row—J. S. Kirkland, Rome Kraft; J. S. Askey, Elliot Co.; E. W. Summers, Westinghouse. Back row—R. M. Brissey, General Electric; L. F. Hayne, Allis-Chalmers; M. J. Osborne, Bowaters; P. Hernick, Electric Machinery Mfg. Co.

Professor F. A. Crosby, University of Maine; T. A. Likos, Westinghouse; S. A. Bobe, Westinghouse; C. L. Eletson, Alton Boxboard; Professor L. C. Jenness, University of Maine; J. L. Ober, Speaker, University of Maine, Pulp & Paper Foundation; L. W. Burr, St. Regis Paper Co.; C. H. Hudson, General Electric; I. M. Witham, Byron Weston; Professor W. J. Creamer, University of Maine; G. E. Shaad, General Electric; S. J. Campbell, Westinghouse

The University of Maine has probably one of the few complete paper machines among universities which is used in their research work on pulp and paper. This is a fourdrinier machine, approximately 11 in. in width, operating at about 300 f.p.m. Laboratories were opened to inspection. Many mills within practical driving distance opened their doors to visits by those attending the conference.

The A.I.E.E. Pulp and Paper Subcommittee meeting was held June 17, during which time it was determined that the 1960 conference would be held in Gainesville, Fla., probably early or mid-April. The meeting to be held in 1961 will likely be in the Mid-Western States area.

The very successful 1959 conference is a result, in a large part, to the excellent cooperation and assistance contributed by the University's Colleges of Engineering and Chemistry, and to the Publicity Department, under the direction of Howard Keyo.

The program Thursday, June 18, consisted of presentations describing "Short Circuit Calculating Boards," "Great Northern Paper Co.'s Power System," "Magnetic Amplifier Power Supplies for Adjustable Speed Drives," "Control Systems for Industrial Nuclear Power Plants," and "High Voltage A.C. Motor Insulation."

The subjects covered June 19 were "Lightning Protection for Paper Mills," "Cable Application in Paper Mills," and "Regulating Systems for the Paper Industry."

Copies of the papers presented are not available until released through A.I.E.E. Headquarters and authors' consent given.

C. H. Hudson, General Electric Co., Atlanta, Ga., is chairman of the A.I.E.E. Pulp and Paper Industry Subcommittee. E. K. Murphy, Rayonier Inc., Jessup, Ga., is vice-chairman, and C. L. Eletson, Alton Box Board Co., Alton, Ill., is secretary.

Eighth Statistics Course

The Eighth Pulp and Paper Statistics Course, jointly sponsored by the Canadian Pulp and Paper Association Technical Section and the Technical Association of the Pulp and Paper Industry was held at Dartmouth College, Hanover, N. H., July 20–31, 1959.

Twenty-one students attended the basic section of the course and twelve participated in the advanced seminar. The names and companies of the students are given below.

Students and staff of the Eighth Statistics Conference

BASIC COURSE

Anderson, Paul R., St. Regis Paper Co., Deferiet, N. Y.
Barker, E. R., III, Albermarle Paper Mfg. Co., Richmond, Va.
Belanger, Lucius, Rolland Paper Co. Ltd., St. Jerome, Que.
Bourget, Guy, Canadian International Paper Co., La Tuque, Que.
Breidenthal, Brooks, Champion Paper and Fibre Co., Hamilton, Ohio
Comeau, Ernest J., Jr., W. R. Grace & Co., Cambridge, Mass.
Correll, Gene M., West Virginia Pulp & Paper Co., Covington, Va.
Foster, Donald, Potlach Forests Inc., Lewiston, Idaho
Germain, Leon V., Canadian International Paper Co., 1017 Sun Life Bldg., Montreal, Que.
Grasse, Kenneth M., Howard Paper Mills Inc., Dayton, Ohio
Hamilton, Richard P., St. Regis Paper Co., Deferiet, N. Y.
Ingram, Hanlon, International Paper Co., Natchez, Miss.
Mapes, David A., Dow Chemical, Midland, Mich.
Millen, R., Anglo-Canadian Pulp & Paper Mills Ltd., Quebec, Que.
Partridge, Harold de V., Brown Co., Berlin, N. H.
Robinson, David B., Diamond Gardner, Plattsburg, N. Y.
Sailors, James R., American Box Board Co., Grand Rapids, Mich.
Samson, Georges E., Anglo-Canadian Pulp & Paper Mills Ltd., Quebec, Que.

The instructors Ralph Wormleighton, University of Toronto; John Mandel, National Bureau of Standards; Geoffrey Beall, Gillette Safety Razor Co.; and Fred Sheldon, Food Machinery & Chemical Corp.

Seguin, Yvan, Canadian International Paper Co., Hawkesbury, Ont.
Snow, H., Bowaters Newfoundland Pulp & Paper Mills, Corner Brook, Nfld.
Valg, Leonid, Columbia Cellulose Co., Ltd., Prince Rupert, B. C.

ADVANCED SEMINAR

Bernier, Miss Gloria A., St. Regis Paper Co., Carthage, N. Y.
Blakely, B. M., Canadian International Paper Co., Three Rivers, Que.
Borchers, Charles H., Lithographic Technical Foundation Inc., Chicago, Ill.
Gates, Jack, American Marietta Co., Seattle, Wash.
Harris, J. W., Spruce Falls Pulp & Paper Co., Kapuskasing, Ont.
Kruger, John R., Consolidated Water Power & Paper Co., Wisconsin Rapids, Wisc.
Martin, John P., Canadian International Paper Co., Temiskaming, Que.
McLimont, D. W., E. B. Eddy, Hull, Que.
Munk, L., Price Bros., Kenogami, Que.
Patrick, Karl, Fraser Cos., Edmundston, N. B.
Randall, D. J., Canadian International Paper Co., Gatineau, Que.
Streb, J. E., Consolidated Water Power & Paper Co., Wisconsin Rapids, Wisc.

STAFF

Beall, Geoffrey, Gillette Safety Razor Co., Boston, Mass.
Mandel, John, National Bureau of Standards, Washington, D. C.
Sheldon, F. R., Food Machinery & Chemical Corp., Princeton, N. J.
Wormleighton, R., University of Toronto, Toronto, Ont.

The instructors for the basic course were Goeffrey Beall, Gillette Safety Razor Co., Boston, Mass., and Fred R. Sheldon, Food Machinery and Chemical Co., Princeton, N. J.

Goeffrey Beall, B.A. (U.B.C.), M.Sc. (Illinois), Ph.D. (London), author of 72 scientific papers, has always worked in experimental design and analysis. He was with the Canadian Dept. of Agriculture, the Ontario Dept. of Health, The Institute of Paper Chemistry, briefly in glass manufacture and meat packing, then chairman of the Dept. of Statistics, University of Connecticut, and is at present statistical advisor to the vice-president for manufacture at Gillette.

F. R. Sheldon, general manager, Applications Section, Inorganic Research & Development Department, Food Machinery & Chemical Corp., Princeton, N. J., prior to moving to Princeton in September, 1958, had been with FMC's Becco Chemical Division since his graduation from M.I.T. in 1939. He has used statistical methods in his work on the applications of Becco's hydrogen peroxide in the pulp and paper, textile and other industries. Co-author of several articles and patents relating to pulp processing, he is a member of the American Chemical Society, the American

Fred Sheldon assists a student in a calculating laboratory session

Geoffrey Beall works out a problem for two students

Society for Quality Control, the American Statistical Association and TAPPI. He is past chairman of the TAPPI Statistics Short Course Subcommittee.

Instructors in the advanced seminar were John Mandel, National Bureau of Standards, Washington, D. C., and Ralph Wormleighton, University of Toronto, Toronto, Ont.

John Mandel was born in Belgium, where he was granted a master's degree in chemistry by the University of Brussels. He did graduate work in mathematical statistics at Columbia University under Hotelling and Wald.

After having worked as a chemist both in Belgium and in this country, he took a position as a statistician in the Division of Organic and Fibrous Materials of the National Bureau of Standards in Washington, D. C. In this position, which he has occupied since 1948, he acts as a consultant in statistics to chemists, physicists and engineers engaged in research on rubber, textiles, paper, and leather.

He is the author or co-author of 36 papers dealing with the development of statistical methods and their application to the physical sciences, particularly in the field of polymeric materials.

Ralph Wormleighton is a professor of mathematics at the University of Toronto. He received his B.A. and M.A. from that school in 1949 and 1950, and his Ph.D. from Princeton University in 1955.

Professor Wormleighton was associated with the Canadian Armament Research and Development Establishment, Defence Research Board in 1952–53. In 1954 he joined the faculty of the University of Toronto and presently has the rank of assistant professor.

Born in Canada in 1920, he served with the Canadian army from July, 1940, until January, 1946.

The statistics course has been held at a different university each year since 1952. It is designed to provide training in both elementary and advanced application of statistical methods in the pulp and paper industry. In the basic course, lectures and laboratory exercises are given in the following subjects: linear regression, correlation coefficient, partial correlation coefficient, significance of regressions and correlations, multiple regression, curvilinear regression, design of experiments, tests of significance, analysis of variance, analysis of variance with two-way classifications, analysis of variance with unbalanced data, analysis of variance with three or more experimental factors, the role of replication.

In the advanced seminar, the group participates in the solution of specific and somewhat involved problems. Each participant is requested to bring with him statistical problems for discussion by the group. The instructors guide the discussions and give informal talks on a variety of subjects.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Ronald G. Bailey, Project Engineer, St. Regis Paper Co., Deferiet, N. Y., a 1958 graduate of Clarkson College of Technology.

Mulford C. Baker, Mill Chief Chemist, Rhinelander Paper Co., Rhinelander, Wis., a 1940 graduate of University of Cincinnati.

Enrico Barazzetti, Operation Manager, Industrial Controls S.A.S., Monza, Italy, a graduate of H. Tech Institút-Zurich.

George C. Baron, Plant Manager, North Side Div., Consolidated Paper Co., Monroe, Mich., attended John Carroll University.

Jack C. Baumgartner, Technical Salesman, The Dow Chemical Co., New Orleans, La., a 1943 graduate of Bethany College.

Duane H. Bond, Project Specialist, Owens-Illinois, Toledo, Ohio, a 1950 graduate of Michigan State University.

Cameron B. Bruce, Bacteriologist, Alchem Ltd., Burlington, Ont., Canada, a 1949 graduate of Ontario Agricultural College.

Dong Bum Chi, Vice-Chief Engineer, Nam Han Paper Manufacturing Co., Seoul, Korea, a 1955 graduate of English College of National Seoul University.

Philip T. Cook, Production Manager, Martin Paper Products Ltd., Regina, Sask., Canada, a 1954 graduate of University of British Columbia.

Robert J. Cummings, Manager, General Services Div., Union Bag-Camp Paper Corp., Savannah, Ga., a 1943 graduate of University of Florida.

Larry J. Czaswicz, Manager, Paper Dept., Hollymatic Corp., Chicago, Ill.

George R. Dahlinger, Sales Engineer, Combustion Engineering, Inc., New York, N. Y., a 1957 graduate of Polytechnic Institute of Brooklyn.

Jacobus C. G. de Nood, Technical Director, Was de Wit N. V., Voorburg, Netherlands, graduate of Technical High School at Dordrecht.

Alec De Richemont, General Manager, Walton & Place, Seine, France.

Elwood O. Dillingham, Research Associate, The Institute of Paper Chemistry, Appleton, Wis., a 1951 graduate of DePauw University, with a Ph.D. degree in 1955 from Purdue University.

Everett F. Ehrlich, Packing Engineer, W. R. Grace and Co., New York, N. Y., a 1951 graduate of University of Alabama.

C. Richard Fairlamb, Treasurer-General Manager, New Era Manufacturing Co., Hawthorne, N. J., a 1940 graduate of U. S. Military Academy.

Andrea Favini, Administrator, Cartiera Favini, Vicenza, Italy.

Robert E. Glavin, Chemist, Arthur D. Little, Inc., West Cambridge, Mass., a-1950 graduate of Boston College.

Gajanan H. Gondhalekar, Superintendent, Handmade Paper Research Institute, Poona, India, a 1940 graduate of College of Agriculture.

George C. Graham, Technical Service Engineer, The Glidden Co., Baltimore, Md., a 1939 graduate of Worcester Polytechnic Institute.

K. Pascoe Grenfell, Application Engineer, General Electric Co., Schenectady, N. Y., a 1934 graduate of Cambridge University.

Ivan K. Guskov, Research Engineer, Continental Can Co., Mt. Vernon, Ohio, a 1938 graduate of University of Belgrade.

Grant D. Hanson, Assistant Director and Head of Serials Dept., Library, Iowa State University of Science and Technology, Ames, Iowa, a 1933 graduate of Augustana College.

Hazim Hasic, Director General of Sulfate Pulp and Kraft Paper Mill, Tvornica Geluloze, Maglaj, Yugoslavia.

Benjamin W. Hicks, Quality Control Supervisor, Continental Can Co., Beaumont, Tex.

William H. Houff, Chemist, Shell Development Co., Emeryville, Calif., a 1950 graduate of William & Mary College, with a Ph.D. degree in 1955 from Michigan State University.

Donald L. Huyser, Manager, Photographic Coating Div., Allied Paper Corp., Kalamazoo, Mich., a 1951 graduate of Western Michigan University.

Heinz Jacobsen, Manager, Prufinstitut fur Kraftpapiere und Papiersacke GmbH., Darmstadt, Germany, a 1949 graduate of University of Gottingen, with D.Ch.E. degree in 1953.

Robert A. Janke, Sales Service Representative, Corn Products Sales Co., Chicago, Ill., a 1950 graduate of University of Wisconsin.

Jerzy Jerzykiewicz, Chief Engineer, Project Office, Fampa Paper Machinery Works, Cieplice Slaskie, Poland, a 1947 graduate of Technical University-Lodz.

S. K. Keshava, Chemist, The Imperial Tobacco Co. of India Ltd., Calcutta, India, a 1949 graduate of Delhi Polytechnic Institute with a D.Ch.E. degree.

Russell N. King, Technical Staff, the Nash Engineering Co., South Norwalk, Conn., a 1940 graduate of University of Notre Dame.

David C. Kirk, Jr., Research Chemist, Ecusta Paper Div., Olin Mathieson Chemical Co., Pisgah Forest, N. C., a 1944 graduate of Lehigh University with a Ph.D. degree in 1953 from State University of Iowa.

Leonard W. Kleiman, Technical Staff, Hammermill Paper Co., Erie, Pa., a 1956 graduate of New York State College of Forestry at Syracuse University.

Kazuo Kojima, Chief of Section, Nagase & Co., Ltd., Nagoya-shi, Japan, a 1940 graduate of Osaka University.

Marvin Legator, Senior Microbiologist, Shell Development Co., Modesto, Calif., a 1951 graduate of the University of Illinois with a Ph.D. degree.

Thomas J. Maddux, Group Maintenance Engineer, The Champion Paper and Fibre Co., Pasedana, Tex., a 1950 graduate of Texas A. & M. College.

Christoph G. Mahring, Technical Engineer, Zellstoff- und Papierfabrik Frantschach AG., Karnten, Austria, a 1946 graduate of Technical University Wien.

Kenneth R. Moehl, Plant Manager, Simplex Paper Corp., Jacksonville, Fla., a 1943 graduate of University of Michigan.

Terrence E. Monaghan, Plant Manager, Sherbrooke Paper Products Ltd., Sherbrooke, Que., Canada.

Alan C. Nixon, Research Supervisor, Shell Development Co., Emeryville, Calif., a 1931 graduate of University of Saskatchowan, with a Ph.D. degree in 1935 from University of California.

Nunzio Perciabosco, Manager, Centro Sperimentale-"E. Paterno"-Per l'Industria della Cellulosa, Palermo, Italy, graduate of University of Palermo with a D.Chem. degree.

Lloyd E. Picard, Supervisor of Experimental Papermaking, Minnesota Mining & Mgf. Co., St. Paul, Minn., a 1944 graduate of University of Minnesota.

Giulio R. Ravasi, Representative, SA. Cartiere Di Verona, Verona, Italy.

A. Edmont Reichmann, Research Manager, The Institute for Research and Design for the Pulp and Paper Industry, Bukharest, Roumania, a 1946 graduate of First Politechnical Institute.

Pedro Rey, President, Potosi S.A., Buenos Aires, Argentina, a 1930 graduate of Buenos Aires University.

Frank A. Ross, Research Engineer, New Era Manufacturing Co., Hawthorne, N. J., a 1933 graduate of Bucknell University.

William S. Shelow, Member of Patent Div., Procter & Gamble, Cincinnati, Ohio, a 1949 graduate of University of Tennessee.

Barnett J. Sledge, General Superintendent, Plant Engineer, Champion Paper and Fibre Co., Canton, N. C., a 1936 graduate of University of Tennessee.

Nicolaas H. Soemers, Research Chemist, Koninklyke Nederlandse Papierfabriek, Maastricht, Netherlands.

Wtoozimierz Surewicz, Scientific Worker, Technical University of Lodz, Lodz, Poland, a 1947 graduate of Technical University of Lodz, with degree of D.Tech.Sc.

Ray N. Taylor, Plastics Coatings Sales, The Dow Chemical Co., Atlanta, Ga., a 1954 graduate of Occidental College.

Richard W. Van Duyn, Operations Analyst, West Virginia Pulp and Paper Co., New York, N. Y., a 1954 graduate of Harvard College.

J. Henry Violette, Chemist, Fraser Paper, Ltd., Madawaska, Me., a 1949 graduate of Pennsylvania Military College.

Frank Wabers, Student, The Institute of Paper Chemistry, Appleton, Wis., a 1955 graduate of University of Wisconsin.

William Webb, Jr., Chief Chemist, Spaulding Fibre Co., No. Rochester, N. H., a 1955 graduate of American International College.

Elizabeth A. Weizenhoffer, Chief Chemist, Polymer Industries, Springdale, Conn., a 1936 graduate of Columbia University.

Sigurd Wendleman, Production Manager, AB Billingsfors-Langed, Billingsfors, Sweden, a 1935 graduate of Technical College, Obrebro, Sweden.

TAPPI Notes

Lamar T. Atwood is now Research Manager of the Multiwall Division of Hudson Pulp & Paper Co., So. Windham, Me.

Ronald L. Benson, formerly Student at the New York College of Forestry, is now a Project Engineer for the Fitchburg Paper Co., Fitchburg, Mass.

Otto T. Bierwagen, formerly of the Eastman Tag & Label Co., is now a Chemist for the California Ink Co., Berkeley, Calif.

Sidney G. Briscoe is now Vice-President in Charge of Sales for Pusey & Jones Corp., Wilmington, Del.

Franklin W. Chandler, formerly of the St. Joe Paper Co., is now with Marathon Southern Corp., Linden, Ala.

Claud B. Christiansen is now Supervisor of Pulp and Paper Technical Service for the Diamond Alkali Co., Painesville, Ohio.

S. Earll Church is now Manager of Technical Service for Rayonier, Inc., New York, N. Y.

Herbert C. Church is now Assistant to the Vice-President of New York & Pennsylvania Co., Lock Haven, Pa.

Joseph C. Clark, formerly of National Container Corp., is now Technical Superintendent of Bowaters Carolina Corp., Catawba, S. C.

George B. Creamer is now Assistant General Manager of Research for Rayonier Inc., New York, N. Y.

Derek Currie, formerly of the Standards Packaging Corp., is now Manager of the Pulp Division of Weyerhaeuser Timber Co., Tacoma, Wash.

Donald R. Curtis, formerly of Hartford City Paper Co., is now an Engineer for Minnesota Mining & Mfg. Co., St. Paul, Minn.

Owen T. Dallay, formerly of Marathon Corp. of Canada, is now Senior Technologist for the Champion Paper & Fibre Co., Canton, N. C.

William R. Denham, Jr., is now Sales Manager for Printing and Fine Papers for Simpson Paper Co., Everett, Wash.

G. Kent Dickerman, Jr., formerly of Minnesota Mining & Mfg. Co., is now a Chemist for the Consolidated Water Power & Paper Co., Appleton, Wis.

Carmin P. Donofrio is now Professor of Pulp and Paper Technology at the New York State College of Forestry, Syracuse, N. Y.

Arthur Z. Dreis, formerly of the Armour Research Foundation, is now a Partner in A. G. Dreis & Associates, Chicago, Ill.

Anthony J. Ferzola, formerly of Charles Bruning Co. Inc., is now a Research Chemist for the Guilford Finishing Co., Guilford, Conn.

Harold L. Field, formerly of Allied Paper Corp., is now Production Manager for the West Jersey Paper Co., Camden, N. J.

Robert J. Gilmer of Owens-Illinois Glass Co. has been transferred from Tomahawk, Wis., to Big Island, Va., as Pulp Mill Superintendent.

Henry M. Greenhouse, formerly of the U. S. Army Chemical Corps, is now Technical Director for the Columbia Box Board Mills, Inc., Chatham, N. Y.

Sherrill J. Hazard, formerly Student at the New York State College of Forestry, is now a Research Engineer for the Consolidated Water Power & Paper Co., Bison, Wis.

Jay G. Herr, formerly Student at the University of Maine, is now Technical Service Engineer for the Brown Co., Berlin, N. H.

John P. Hollihan, Jr., of Rayonier, Inc., has been transferred from New York, N. Y., to Whippany, N. J., as Assistant Manager of the Eastern Research Division.

Richard H. Hudson is now Plant Superintendent of the Pomeroy Mfg. Div. of Central Fibre Products Co., Vincennes, Ind.

Farhang Javid, formerly of The Black-Clawson Co., is now Vice-President and Sales Manager of Smith & Winchester Co., So. Windham, Conn.

James W. Jelks, formerly of the Jelks Co., is now a Staff Engineer for Alton Box Board Co., Alton, Ill.

Rudolph W. Kugler, formerly of Courtaulds, Inc., is now Assistant to the President of Cary Chemicals, Inc., New Brunswick, N. J.

Carl C. Landegger, Administrative Vice-President of the Black-Clawson Co., has moved his office from Watertown, N. Y., to New York, N. Y.

Renata Marton is now Assistant Professor of Pulp and Paper Technology at the New York State College of Forestry, Syracuse, N. Y.

Kenneth W. McClean, formerly of Hart Products Co., is now a Technical Representative for St. Lawrence Starch Co., Port Credit, Ont.

Frank E. Monks, formerly of The Fuller Label & Box Co., is now Senior Process Engineer for the Aluminum Co. of America, Davenport, Iowa.

Robert H. Nitz, formerly of the Sutherland Paper Co., is now a Technical Project Assistant for the American Box Board Co., Filer City, Mich.

Richard W. O'Donnell, formerly of Potlatch Forests, Inc., is now Assistant Pulp Mill Superintendent for Bowaters Carolina Corp., Catawba, S. C.

Richard V. Osborn is now Director of Product Planning for the Great Northern Paper Co., Millinocket, Me.

H. B. Peterson of the PMC Dept. Hercules Powder Co. has been transferred from Milwaukee, Wis., to Portland, Ore.

Edward M. Root, formerly of Black-Clawson (Canada) Ltd., is now Manager of Sales for the Black-Clawson Co., Shartle Div., Middletown, Ohio.

Jerome Rose, formerly Student of the New York State College of Forestry, is now a Trainee for Container Corp. of America, Chicago, Ill.

Ernest L. Ross, formerly Student of the North Carolina State College, is now with the Champion Paper & Fibre Co., Pasadena, Tex.

James R. Schoettler, formerly of Consolidated Water Power & Paper Co., is now Technical Director for the Great Northern Paper Co., Millinocket, Me.

William Schul, formerly of North Carolina State College, is now a Technical Service Engineer for the Champion Paper & Fibre Co., Hamilton, Ohio.

George E. Scofield is now General Manager of Cellulose Operations of Rayonier, Inc., New York, N. Y.

Jackson L. Smilie, formerly of the Container Corp. of America, is now Associate Engineer for the International Paper Co., Moss Point, Miss.

Delmont L. Smith is now Manager of The Eastern Research Division of Rayonier, Inc., Whippany, N. J.

Hiram L. Smith, Jr., formerly of Stone & Webster Engineering Corp., is now with The Bowen Corp., Cambridge, Mass.

R. H. Stevens has retired as Research Associate at the Herty Foundation Laboratory and will reside in Ridgecrest, N. C.

Elmer K. Stilbert, Jr., is now Vice-President of the Product Group, Dow Chemical Co., Midland, Mich.

Edward O. Travis, formerly of J. E. Sirrine Co., is now an Engineer with Eastern Engineering Co., Atlanta, Ga.

Erik B. Ungern, formerly of the Lee Paper Co., is now Assistant Production Manager for the Cel-Fibre Division, Personal Products Corp., Milltown, N. J.

Jerrold A. Walecka, formerly of the West Virginia Pulp & Paper Co., is now a Research Chemist for the Mead Corp., Chillicothe, Ohio.

William A. Welsh, Jr., formerly of the Container Corp. of America, is now a Process Evaluation Engineer for the Gulf States Paper Corp., Demopolis, Ala.

Industry Notes

Production

Paper and board production during April amounted to 2,911,915 tons. This was 17% above the 2,498,020 tons produced in April a year ago. Paper production amounted to 1,270,360 tons, which was 12% above the 1,136,435 tons produced in April a year ago. The output of paperboard during this month was 1,340,690 tons, reflecting a 21% increase above the production of 1,110,899 tons reported for April, 1958.

Pulpwood

Total receipts of pulpwood for the first four months of 1959 were 11,983,000 cords, an increase of 813,000 cords over receipts for the comparable period of 1958. Domestic receipts were 890,000 cords above the year earlier total, while imports declined 77,000 cords. The South Atlantic region was the only region showing a decrease in receipts of pulpwood, declining 15% below the first four months of 1958.

Pulpwood consumption in the first four months of 1959 was 12,635,000 cords, an increase of 1,059,000 cords over the same period of 1958. The Northeastern region showed a 1% decline in consumption while all other regions showed increases, ranging from 5% in the West to 13% in the South Atlantic region.

Inventories of pulpwood at the end of April were 5,295,000 cords, a decrease of 441,000 cords below March, 1959, and 15% decline from April last year. All of the regions showed decreases, ranging from 3% in the South Central to 28% in the West.

Wastepaper

April wastepaper receipts were 803,000 tons; for the first four months of this year they totaled 3,074,000 tons, an increase of 334,000 tons above receipts for the first four months of last year.

Wastepaper consumption for April was 787,000 tons; the January–April total was 3,040,000 tons, an increase of 274,000 tons above consumption for the first four months in 1958.

Inventories at the end of April were 472,000 tons, an increase of 16,000 tons above March, but 34,000 tons below inventories at the end of April, 1958.

Consumption of total fibrous materials for April was 882,000 tons; the January–April total was 3,394,000 tons, an increase of 287,000 tons above consumption for the first four months of 1958.

Inventories of total fibrous materials at the end of April were 905,000 tons, 12,000 tons below March, and 53,000 tons below inventories at the end of April, 1958.

Wood Pulp

Production of wood pulp for the first four months of 1959 was 7,890,000 tons, an increase of 819,000 tons above the comparable 1958 total.

Wood pulp consumption in the manufacture of paper and board for the first four months of 1959 was 8,156,000 tons, an increase of 907,000 tons above consumption for the first four months of 1958.

Imports of wood pulp for January–April, 1959, were 796,018 tons, an increase of 24% above imports for the first four months of last year. Imports from Canada for the first four months of 1959 were 646,842 tons, an increase of 16% over the comparable period of 1958. Overseas imports for the first four months of 1959 were 147,135 tons as compared to 86,022 tons in the first four months of 1958.

Exports of wood pulp for the first four months of this year were 196,623 tons, as against 182,427 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of April were 547,000 tons an increase of 1000 tons above inventories at the end of March, but 1000 tons below inventories at the end of April, 1958.

Folding Boxes

June shipments of folding boxes advanced vigorously, topping the year-ago dollar volume by 6.2%, the Folding Paper Box Association of America has announced. Tonnage for the month was 4.6% ahead of June of last year.

Increased business in June, added to gains recorded in April and May, boosted carton volume in the second quarter to 5.8% above year-ago levels. Tonnage in the three-month period was 4.6% ahead of 1958.

Totals for the half year show dollar volume 4% and tonnage 3.4% ahead of the first half of 1958. The brisk rise in folding carton business extended to every section of the country, with dollar volume in the first six months of 1959 ranging from 2 to 13% ahead of last year.

Most improved area was the Pacific coast, followed by the North Central, Eastern, and Southern areas in that order.

Tonnage through June, 1959, topped carton shipments in the first half of 1958 by margins ranging from 1 to 17% in all but the Southeast and Missouri Valley.

Industry volume in June totaled $79,100,000, setting a new high for any June on record. Total shipments during the month were 198,114 tons, almost 8000 tons above June of last year.

At the half-year mark, two out of three plants had improved their year-ago volume. Plants having an annual volume of less than $1,000,000 recorded the biggest gains, averaging 21% over last year.

Reports of new orders keep improving. New bookings in June were up 6% tonnage-wise and 8% in dollars. For the first six months of 1959, orders are well above the same period of last year. Measured in dollar volume, new orders were ahead 7.4% and tonnage was up 6.6%.

W.P.U.C.

A new bulletin entitled, "The Waste Paper Utilization Council Why, What, Who, How?" is available from the Council at 122 E. 42nd St., New York 17, N. Y. This is a revision of the old bulletin entitled, "The Waste Paper Utilization Council Improving Waste Paper Supplies." It is designed primarily for the benefit of those who may be considering membership in the Council and a special effort has been made to give it an attractive appearance. Information that is subject to change from time to time is inserted in a back pocket so that it can be kept up to date as copies are issued. There is a substantial supply of these booklets in the Council office and copies are available to all who request them.

I.S.C.C.

The 29th Annual Meeting of the Inter-Society Color Council will be held at the Philadelphia Museum College of Art, Philadelphia, Pa., on Monday and Tuesday, April 11 and 12, 1960.

On Monday, April 11, meetings of the color problems subcommittees will be held.

The annual business meeting will be on Tuesday morning, April 12. During the afternoon a symposium will be held under the general title of "Creative Color." The banquet will be held on Tuesday evening.

For further information, write: Ralph M. Evans, Secretary, Inter-Society Color Council, Color Technology Division, Building 65, Eastman Kodak Co. Rochester 4, N. Y.

Verdict Reversed

In the litigation pending between Scapa Dryers, Inc. of Waycross, Ga., and Abney Mills of Greenville, S. C., the United States Court of Appeals for the Fifth Circuit has unanimously reversed the judgment rendered last February in favor of Abney Mills and directed the entry of a judgment in favor of Scapa Dryers, Inc. The judgment which the Court of Appeals reversed had enjoined the Hindle-Scapa interests from using or operating Hindle looms in the manufacture of drier felts in this country. The effect of the reversal is to confirm the right of Scapa Dryers, Inc. to continue to operate and to enlarge the capacity of its plant located in Waycross, Ga., which has been supplying Scapa drier felts woven on Hindle looms to the United States paper industry since 1956.

Tunisia

Building of the first large scale esparto pulp mill in North Africa is being undertaken by Societe Nationale Tunisienne de Cellulose. The contract for construction of the $11,-

New Plants and Facilities

Firm	*Location*	*Products*	*Dollars*	*Job status*
Boise Cascade Corp.	Attalia, Wash.	Pulp, paper containers	Multi-million	Container plant in operation in spring, 1958; pulp and paper facilities on stream 18–24 mo. afterwards.
Boise Cascade Corp.	Wallula, Wash.	Pulp and paper	15 million	New mill expected on stream early 1959.
Brown Co.	Berlin, N. H.	Specialty pulp products	5.3 million	Conversion to continuous magnesia-base pulping in April 1958, aids pollution control, recovers pulping chemicals at 400-ton/day plant.
Brunswick Pulp & Paper Co.	Brunswick, Ga.	Chloride dioxide	3 million	Chlorine dioxide bleach plant, completed mid-1958, for use in pulp manufacture.
Buckeye Cellulose Corp.	Foley, Fla.	Cellulose pulp	Multi-million	Capacity doubled late 1958.
Champion Paper & Fibre Co.	Fairfield, Calif.	Pulp and paper	....	300-ton/day mill began construction mid-1958.
Container Corp. of America	Arlington, Tex.	Folding cartons	2.5 million	Ready for occupancy in second half of 1959.
Crown Zellerbach Corp.	Camas, Wash.	Pulp and paper	800,000	New chlorine dioxide unit now being added to kraft bleach plant.
Eastern Corp.	Lincoln, Me.	Bleached kraft pulp	11 million	175-ton/day mill started mid-1958.
Gulf States Paper Corp.	Demopolis, Ala.	Bleached sulphate pulp	....	300-ton/day plant on stream late 1958.
Kerncot Fibre Corp.	Buttonwillow, Calif.	Pulp	Multi-million	Plant under construction mid-1958 converts cotton stalks into paper pulp.
Marathon Southern Corp.	Naheola, Ala.	Pulp, paper, paperboard	40 million	Mill on stream late 1958.
Noralyn Paper Mills	Donaldson, La.	Newsprint	....	Construction started late 1958 on 150-ton/day plant; capacity can be upped to 250 tons/day
Olin Mathieson	Joliet, Ill.	Corrugated paperboard	....	30-million-sq. ft./mo. facilities under construction 1958.
Oxford Paper Co.	Rumford, Me.	Kraft pulp	15 million	Three-year improvement program includes: new 175-ton/day softwood kraft mill, new chlorine dioxide bleaching system, increase in hardwood kraft capacity from 250 to 350 tons/day.
Puget Sound Pulp & Timber Co.	Bellingham, Wash.	Pulping by-products	400,000	Expansion includes doubling production of alcohol from lignin.
Rayonier	Jesup, Ga.	Pulp, chemical cellulose	25 million	Second 100,000-ton/yr. plant opened early 1958.
Southern Chemical Cotton Co.	Chattanooga, Tenn.	Industrial filter paper	....	New 30,000-lb./day facilities will be completed late 1959.
West Virginia Pulp & Paper Co.	Charleston, S. C.	Paper	....	Plant capacity expanded to 150,000 tons/yr. of stretchable paper.
West Virginia Pulp & Paper Co.	Luke, Md.	Pulp and paper	50 million	Long-range building plans will add 750 tons/day to capacity over the next five years.
West Virginia Pulp & Paper Co.	Torrance, Calif.	Multiwall bags	....	New plant on stream mid-1958.

000,000 plant has been awarded to the Parsons & Whittemore/Lyddon Organization. Parsons & Whittemore/Lyddon will direct the over-all planning, equipment supply, erection, and start-up of a mill to produce 80 metric tons per day of bleached esparto pulp for world markets.

The mill will be built at Kasserine, well-known World War II battle ground in western Tunisia near the Algerian border. The site is in the heart of Tunisia's esparto growing region. Construction will begin immediately of a completely integrated plant, producing its own steam, electric power, and pulping chemicals.

The company is a Tunisian corporation with share capital subscribed half by the Government of Tunisia and half by private European and North American interests. Substantial aid in financing the project comes from a credit of $6,250,000 extended by the Development Loan Fund, Washington, D. C.

By granting these credit facilities the Development Loan Fund gives a strong boost to the economic development program of the new Tunisian government. Esparto grass, an ideal source of pulp for fine papers, has long been a valuable export commodity in the Tunisian economy. By converting the esparto into pulp Tunisia will produce a more valuable commodity which will immediately increase the country's export receipts substantially.

The mill will provide permanent jobs to about 250 workers and become the means of support of at least 750 more people in a country burdened with unemployment.

In accord with long range government plans for Tunisian economic growth, this mill provides the nucleus for development of the Kasserine area—traditionally agricultural—into a center of population and industrial activity.

Throughout the preliminary stages of the S.N.T.C. project, Parsons & Whittemore/Lyddon pulping experts and economists worked closely with Tunisian officials to produce comprehensive field surveys, cost analyses, and market studies which established the technical and economic feasibility of the project. The engineering services of Stadler, Hurter International, Ltd., Montreal, have been retained.

Pulping Facilities

The mill will receive esparto grass both loose and in bales. The grass will be cooked continuously by the soda process in Pandia Chemipulper equipment built by The Black-Clawson Co. An alkali recovery plant will be provided to recover caustic soda and provide steam for cooking and evaporating. Caustic soda will be produced on the site by an electrolytic plant using sea salt as a raw material. This plant will also produce 5 tons per day of chlorine for use in the bleach plant.

The digested pulp, following coarse and fine screening and two-stage washing, goes to the bleaching plant, consisting of chlorination, caustic extraction, and hypochlorite stages.

The bleached pulp is further cleaned through a centrifugal cleaning system and is then dried on a fourdrinier forming machine with three presses, two predriers, and a tunnel-type air drier. The entire forming machine will be built by Black-Clawson International, Ltd., London.

Power and Water Facilities

All power required for complete operation of the mill will be generated by a 6000-kw. turbine operating on steam from an auxiliary boiler and from the recovery boiler.

To insure an adequate supply of water suitable for the production of high quality bleached pulp, a dam on the Oued Darb River will be enlarged by the Tunisian government to provide a reservoir of 53,000,000 gallons, from which the mill will draw its requirements.

Before entering the process, all mill water will receive conventioanl lime-alum treatment and filtration, and 20% of all water will be completely demineralized for use in final washing of the pulp.

Esparto—History and Characteristics

The special and highly desirable qualities of pulp made from esparto grass have long been recognized by papermakers. The fine printing and writing paper mills in Great Britain, in particular, import large quantities of the raw grass from North Africa and Spain. For many years, esparto grass has been a principal export of Tunisia.

Total exports of the material from North Africa have reached 350,000 metric tons per annum, and all this time British industry has had to assume the high-bulk freight cost of getting the grass to its mills.

Apart from a small 30-ton per day mill in Algeria, no attempt has been made until now to convert North African esparto into pulp at the source of supply. The mill that Parsons & Whittemore/Lyddon has begun to build for Societe Nationale Tunisienne de Cellulose is expected to set an example of productive opportunity for other esparto-growing areas of North Africa.

A new supply of marketable esparto pulp will also attract new consumers in the papermaking world. The esparto fiber, as many established users have found, has characteristics of dimensional stability, printability, bulk, and resilience that cannot be found in any other pulp.

Esparto fibers are short and round compared to the flatness and length of wood fibers. This structure allows sheet formation with high porosity and greater bulk per weight than wood fiber papers. Thus esparto paper receives printing impresses like a cushion, absorbs ink quickly, and renders an exceptionally sharp result.

The dimensional stability of esparto papers is also an attribute of this unique fiber's structure. When exposed to moisture, air-dry esparto fibers simply do not widen and elongate to the much greater extent of wood fibers.

Micropulping Method

The Institute of Paper Chemistry has developed a micropulping technique, which, together with measurements of zero-span fiber tensile strength and fiber length is used as a means of identifying and evaluating trees selected and developed in genetic improvement programs. This was announced June 10, 1959, in Raleigh, N. C., at the annual meeting of the sponsors of The Institute of Paper Chemistry project on the application of pulping and papermaking sciences to the genetic improvement of southern pulpwoods. Attending the meeting for Riegel Paper Corp. were C. R. Calkins, Robert Richardson, E. S. Thornton, and J. D. Wethern; for Union Bag-Camp Paper Corp., J. W. Johnson; for West Virginia Pulp and Paper Co., D. Y. Lenhart and J. J. Wiley; and for The Institute of Paper Chemistry, P. N. Joranson, D. J. MacLaurin, J. P. Van Buijtenen, and W. M. Van Horn.

The project has as one of its initial objectives the development of methods which will reveal and measure superior papermaking qualities in pulps made from candidate parent trees. Because fiber strength and fiber length are of such importance to such a large variety of paper grades, particularly in the South, they have been chosen as desirable pulp qualities with which to work in the initial phases.

Wood samples from outstanding loblolly pine trees which had been selected by sponsoring company foresters, by Bruce Zobel of North Carolina State College, and by institute geneticists were taken by means of increment borers by conventional methods. A technique had to be developed through which chemical analyses and pulping behavior of such small samples of wood could be determined. This has been done by the Pulping and Papermaking Section of the institute. The resulting pulps were evaluated for fiber length, and fiber strength as indicated by the zero-span tensile strength test.

The results to date indicate that there is a significant difference in fiber strength and fiber length of pulps made from different trees in a given stand. This suggests that fiber strength and fiber length might profitably be used by the geneticist as suitable criteria for wood evaluation in a tree improvement program.

Maintenance Annual

The 10th volume in the annual series, "Techniques of Plant Maintenance & Engineering," is, appropriately, the most comprehensive of those published in the past decade.

The volume, published by Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y., is priced at $10 postpaid. It is bound in cloth-on-board, contains 266 pages, and contains all papers read at the 1959 Plant Maintenance & Engineering Conference held in Cleveland last January.

One of the major features of the book is the vast number of practical situations it covers. Included are answers to 1056 questions submitted by engineers attending the conference. More than 70 charts, graphs, and diagrams are reproduced.

Color

In a color-measurement study by Kenneth L. Kelly of the National Bureau of Standards, central notations have been determined for the ISCC-NBS colorname blocks. These blocks are defined as segments of a solid figure, each segment encompassing the range of color acceptable under one color name. Fitted together, the segments comprise the psychological color solid that scientists use to explain gradations in color perceived by the human eye.

The central notations of the blocks have been designated in terms of the Munsell tri-dimensional scales, and paint-on-paper prototypes of the centroid color of each block are being produced. After the prototypes have been approved by the ISCC (Inter-Society Color Council) and NBS, the bureau plans eventually to reproduce the colors as a color-chart supplement to NBS Circular 553, *ISCC-NBS Method of Designating Colors and A Dictionary of Color Names.*

First published three years ago, Circular 553 is now in its third printing. It is employed as a tool by the scientist, the businessman, and the layman to correlate the thousands of different names given to colors by art, science, and technology. These color names are listed in the circular under headings derived from the color-name blocks. The varied applications to which the circular has been adapted by the general public have created a need for a color chart to illustrate the blocks. The present study was therefore made to determine the block centroids from which representative color samples could be produced.

In making the computations, the ISCC-NBS method of designating colors was followed. In this method, the psychological color solid is visualized as a lopsided grapefruit with an irregularly indented outer skin. Its vertical core is white at the top, black at the bottom, with the intermediate grays in between. The characteristic of color varying along this vertical axis is known as *lightness;* it indicates how dark or light the color is, and is measured by Munsell *value.*

The second characteristic of color is known as *hue.* Hue is indicated by the name given to a color, such as red, yellow, green, or blue. These four spectrum hues, plus the nonspectrum hue, purple, are thought of as evenly spaced around the equator of the grapefruit in accord with the Munsell hue scale. Elsewhere in the solid are placed for all the possible colors; light ones near the top; dark ones near the bottom; and the grayish colors surrounding the grays at the core.

Saturation, the third characteristic of color, indicates the departure of a color from gray. This quality is measured by Munsell *chroma* which gives the distance of the color location in the solid from the core. The most saturated or strongest colors are located on the skin. Those with little saturation, such as purplish black, purplish gray, or purplish white, lie along the core or vertical axis.

In the ISCC-NBS method of designating colors, a set of simple, unambiguous hue names is utilized. They are combined with modifiers to form combinations such as light blue, dark red, moderate yellow green, and vivid pink. The complete set of color names including white, the grays, and black totals 267, and the names may be used to describe any color. The color-name blocks are not cubes; the inner blocks are composed of sectors of cylinder. It was therefore necessary to use a mathematical formula in terms of Munsell *hue, value,* and *chroma* to determine the numerical designations of the centroids. With the formula, the centroid of a single or one-component block could be calculated from its hue, value, and chroma ranges. However, to find the centroid of a compound or two-component block, the volume-weighted mean of the central notations of the two components had to be computed. The resultant centroid lies on the straight line joining the centroids of the component blocks.

For a three-component block, the centroid for two of the adjacent blocks was found, and then combined by the same method with the centroid of the third block. The value notation of the resultant centroid was computed as the volume-weighted mean of the value notations of the three separate centroids. The formula is not applicable to color-name blocks that intersect the irregular outer surface or skin of the color solid. For these blocks the centroid was estimated graphically.

When the centroid color samples become available they will be made into special charts for the use of a committee of the Inter-Society Color Council which is investigating historical color usage. The centroid colors may ultimately be incorporated as an appendix in a second edition of NBS Circular 553.

New England Tree Seed Crop

Forest tree seed crops in 1958 were considerably better than those in 1957, according to observers. However, heavy and medium seed crops of some species were spotty in occurrence. Late spring frosts were probably responsible for poor or failing crops of some species in Vermont, New Hampshire, and northwestern Connecticut. Cone weevils were reported damaging the white pine crop in southwestern Maine, southern New Hampshire, and central and northwestern Massachusetts. Insects also damaged seed of white spruce in northern Maine, balsam fir in south-central Maine, and hemlock locally in south-central Connecticut.

In general, most conifers produced heavy to medium seed crops. White pine bore a heavy crop generally over Maine (medium in the southwestern part due to cone weevil). Elsewhere in New England, the white pine crop was spotty. Production was heavy in parts of northern Vermont, Massachusetts, and Rhode Island and light to very light in Connecticut and New Hampshire. Failures were noted in northern New Hampshire and central Vermont. Red pine had a medium crop in parts of Maine and Connecticut and light to a failure in other areas.

White spruce and balsam fir seed production was medium to heavy in Maine. Fir had a medium crop in Vermont and northern Massachusetts. Red spruce was spotty throughout the region, with heavy crops confined to parts of Maine and Massachusetts. Eastern hemlock was heavy in most of Massachusetts, Connecticut, and in northern New Hampshire, but was spotty in the rest of New England.

Tamarack seed crop was reported heavy in Maine and New Hampshire. Northern white-cedar crops were spotty, with medium to heavy crops reported in Connecticut and parts of Maine and Vermont. The crop of eastern redcedar seed was heavy in Connecticut and medium in southern Vermont.

Among hardwood species, the red and sugar maples bore heavy crops in all states, although there were spotty reports of lighter crops. Birch seed crops were also variable.

Bolton Award

Mrs. Ann E. Burke, personnel records clerk, Marinette Paper Co., Marinette, Wis., won first prize of $1000 for her essay in the 12th Bolton Award Contest.

Second prize of $750 went to G. W. Hackett, personnel manager, Container Corp. of America, Santa Clara, Calif. The third prize of $500 was won by Miss Jacqueline Fandrey, personnel secretary, Bergstrom Paper Co., Neenah, Wis.

Ann E. Burke, 12th Bolton Award winner

Announcement of this year's 10 contest winners was made by Haigh M. Reiniger, vice-president of John W. Bolton & Sons, Inc., in a talk delivered at the 40th annual Convention of The American Pulp and Paper Mill Superintendents at Houston, Tex.

Mr. Reiniger stressed the fine cooperation received from the APPMSA, as cosponsors of this annual essay competition, and expressed satisfaction at the manner in which employees and management of the North American pulp and paper industry have given active support to the Bolton Award. "Started as a method of fostering a free exchange of ideas on matters of common interest in 1944, the Bolton Award has since become an established institution within the industry, having no parallel as a unique source of timely information," he said.

The subject of the 12th Bolton Award was "I Want to Be Kept Informed." Wide participation in this contest indicates a broad scope of interest in company communications and a wealth of ideas and opinions on the subject. As in other years, the ten winning essays will be distributed in bound volumes throughout the pulp and paper industry. Distribution of the 12th Bolton Award books will be made in the fall.

Other prize winners were:

James Stoll, Senior Industrial Engineer, Crown Zellerbach Corp., Camas, Wash.
Daneen Marilyn Geer, Jr., Budget Control Clerk, Sutherland Paper Co., Kalamazoo, Mich.
Robert A. Bagg, Mill Visit Host, Strathmore Paper Co., West Springfield, Mass.
Glendora E. Henry, Switchboard Operator & Receptionist, Schmidt & Ault Paper Co., York, Pa.
Norman B. Whittier, Budget Director, Hammermill Paper Co., Erie, Pa.
George C. Sisler, Asst. Paper Mill Superintendent, Bergstrom Paper Co., Neenah, Wis.
Alfred A. Mann, Asst. Pulp Mill Superintendent, S. D. Warren Co., Cumberland Mills, Me.

Tennessee River

G. W. E. Nicholson, president, has announced that the Tennessee River Pulp & Paper Co., Counce, Tenn., has made the following appointments: Dan R. Pichon Jr., formerly manager of industrial relations with the Dierks Paper Co., Pine Bluff, Ark., has been made manager of industrial and public relations. Lawrence T. Coker, formerly engineer with the Hollingsworth & Whitney Division of Scott Paper Co., Mobile, Ala., has been appointed to position of senior engineer.

I.P.

Plans for addition of a third paper machine at International Paper Co. new Pine Bluff mill were announced recently by Richard C. Doane, president, following approval of the proposal by the company's board of directors.

The original two units at the Pine Bluff mill began operation in July, 1958, producing newsprint and bleached kraft board.

The new 209-in. Beloit machine will be equipped to manufacture lightweight directory papers and other groundwood printing grades to meet the expanding demand for these grades in the South and Southwest. It will have a rated capacity of 50,000 tons annually. In addition to the construction necessary to house the machine itself, there will be related additions to the groundwood mill and a new recovery boiler will be added to the power plant.

Mr. Doane said that the new unit is expected to be completed by January, 1961. Total cost for the expansion program is estimated over $13 million. It is expected that in excess of 100 additional persons will be employed at the mill when the entire program is completed.

International Paper is currently purchasing approximately 85% of the wood used at Pine Bluff from independent tree farmers throughout the state of Arkansas. The wood is delivered through 11 mechanized pulpwood concentration yards located in timber growing areas to provide convenient local markets where pulpwood may be sold directly to the company.

Arkansas is an important timber growing state, ranking fifth in the nation in the number of tree farms. The timber harvest provides an important cash crop for the state's farmers and small landowners.

Mr. Doane said that International Paper currently employs 1100 men and women at the Pine Bluff mill with an additional 2500 employees located at its mill and converting plant in Camden, at the Long-Bell plants in Sheridan and Fort Smith and in its woodland operations.

Brown

A new addition to its Cascade paper mill will be constructed immediately by Brown Co., pulp, paper, and other forest products manufacturer, it was announced July 14. The new structure, to cost nearly $200,000 will adjoin the present Cascade mill located in the town of Gorham, N. H.

In announcing the addition to its present plants here, A. E. H. Fair, Brown Co. president said, "Increased demand for our newly established line of fine papers, as well as necessity for adding to present facilities manufacturing our Nibroc paper lines, makes it necessary for us to add to the Cascade mill. The new structure will provide additional space for paper converting and finishing equipment, thus enabling us to operate at lower cost and to provide better customer service in the flexible packaging, envelope and printing paper trade."

Mr. Fair added that the new building will also include a modern truck loading terminal which he said will enable Brown Co. to speed deliveries.

Mead

James S. Evans has been elected vice-president and general manager of The Wrenn Paper Co., Middletown, Ohio, wholly-owned subsidiary of The Mead Corp., it has been announced by Mead President D. F. Morris.

Mr. Evans, associated with Mead for 13 years, was transferred to Middletown as Wrenn's mill manager in November, 1958, and had been acting general manager since the death of J. J. Hallowell, Wrenn president, on March 20, 1959.

He began his career with Mead in 1946 as an engineering trainee and was director of production-quality control at the Kingsport, Tenn., division prior to joining Wrenn.

In his new position as operating head, he will be responsible for the sales and production of The Wrenn Paper Co., manufacturers of technical papers for the decorating and industrial laminating industries.

Mr. Evans is also a member of Wrenn's board of directors.

Election of Engelbert F. T. Krichels as vice-president, manufacturing and James M. Burt, vice-president, sales, of Hurlbut Paper Co., South Lee, Mass., was announced July 13 by E. A. Sitzer, president.

The promotions highlight careers of 29 years for Mr.

E. F. T. Krichels, The Hurlbut Paper Co.

J. M. Burt, The Hurlbut Paper Co.

Krichels and 20 years for Mr. Burt with Hurlbut, wholly-owned subsidiary of The Mead Corp.

Hurlbut Paper Co., founded in 1806, manufactures special technical papers for the decorating and industrial laminating industries, filter papers, and photographic base papers. Mr. Krichels and Mr. Burt will be responsible for the production and sale of all papers made at the company's two mills in South Lee.

Mr. Krichels, native of Olef, Kreis, Schleiden, Germany, joined Hurlbut in 1930 as a chemist. In succeeding years, he was named to the following positions: chief chemist, 1934; superintendent, 1939; and general superintendent, 1947. He was a director of the company from 1944 through 1957.

Mr. Burt began his career with Hurlbut as a chemist in July, 1939, after graduating from Norwich University where he majored in chemistry.

His employment was interrupted for five years, 1941–46, while he served with Co. B, 66th Armored Regiment, 2nd Armored Division of the U. S. Army. For heroic action in battle on the western outskirts of Wurselen, Germany, in October, 1944, he was awarded the Congressional Medal of Honor by President Truman in August, 1945.

Following his discharge with the rank of captain he rejoined Hurlbut as technical sales representative. In 1951 he was named sales manager, position he held at the time of his promotion. He was secretary of the company from 1952 through 1957.

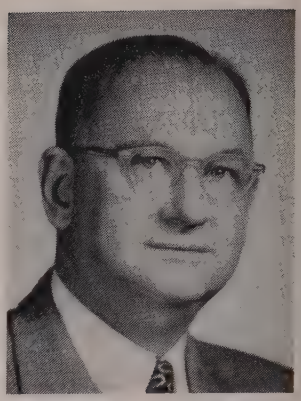
C.Z.

H. L. Zellerbach, acting board chairman of Crown Zellerbach Corp., has announced that the board of directors had approved a general realignment of executive duties and responsibilities. Mr. Zellerbach explained that organizational adjustments had become advisable because of the company's rapid growth and recent and pending retirements at the top management level.

A. B. Layton, Crown Zellerbach Corp.

R. O. Hunt, Crown Zellerbach Corp.

A. B. Layton has been elected chairman of the newly established Finance Committee and will preside at stockholders' meetings and meetings of the board and executive committee in the absence of J. D. and H. I. Zellerbach. To be free from day-to-day administrative duties, Mr. Layton relinquishes his post as president and administrative officer. Reed O. Hunt, who has been serving as executive vice-president and chief operations officer, has been elected president and chief executive officer of the corporation.



P. T. Sinclair, Crown Zellerbach Corp.

P. T. Sinclair, who has been president of Crown Zellerbach Canada Ltd. with headquarters in Vancouver, B. C., has been elected executive vice-president of the corporation. The board of directors of Crown Canada has elected as his successor G. H. Gallaway, who has been assistant vice-president for manufacturing at corporate headquarters in San Francisco.

Action by the Board also includes the consolidation of executive responsibilities in the packaging segments of the company's business. D. J. Benjamin, vice-president of the corporation and general manager of the Western-Waxide Division, assumes the new post of vice-president for packaging operations. Lloyd Merwin, vice-president of the corporation in charge of converting operations of the Gaylord Container Corp. Division, will continue his present duties and report to Mr. Benjamin.

C. S. Cullenbine, secretary of the corporation, has been elected vice-president for administration and will also continue to serve as secretary.

F. O. Boylon, resident manager of Crown Zellerbach's Camas, Wash., paper mill, has been named assistant vice-president for manufacturing, San Francisco headquarters, it has been announced by E. W. Erickson, vice-president, manufacturing and construction. Mr. Boylon succeeds G. H. Gallaway who moves to Vancouver, B. C., as president of Crown Zellerbach Canada Ltd.

A native of Ada, Mich., Mr. Boylon is a graduate of the University of Michigan with a B.S. in mechanical engineering. He worked 14 years in the paper industry before joining Crown Zellerbach as paper machine superintendent at Camas in 1948. In 1950 he was promoted to assistant resident manager of Crown Zellerbach Canada's Ocean Falls, B. C., mill, and, in 1953, he returned to Camas as assistant resident manager. He was promoted to resident manager there in 1956.

R. A. Butler, assistant resident manager, will succeed Mr. Boylon as resident manager at Camas. Mr. Butler is a native of Cazadero, Ore., and a chemical engineering graduate of Oregon State College. He joined Crown Zellerbach at Camas in 1939 as a pulp test helper and has been assistant resident manager at Camas since 1956.

Mosinee

William J. White has been appointed manager of technical sales service for Mosinee Paper Mills Co. It is a new position in the organization, created for the purpose of better serving customers on a technical level. This includes work in the customers' plants as well as in the Mosinee mill.

Mr. White, a graduate of the University of Maine, started his career in the paper industry while a student in high school 35 years ago. He has been in the industry ever since, serving such companies as Kalamazoo Vegetable Parchment Co., Chillicothe Paper Co., Munising Paper Co., and Stevens Paper Mills.

In 1956 White joined the Mosinee, Wis., firm as supervisor of process research.

Consolidated Water Power

Five new men have joined the Research and Development Department of Consolidated Water Power & Paper Co., it has been announced by S. G. Holt, research manager.

Sherrill J. Hazard, Jr., and Walter Rew joined the department staff as project engineers. Mr. Hazard is a 1959 graduate of New York College of Forestry, Syracuse, with a master's degree in pulp and paper technology. Mr. Rew received a B.S. degree in paper technology from the same university in 1956 and has been employed by West Virginia Pulp & Paper Co.

Jaakko Niilo-Rama joins the department as a project chemist. He is a native of Finland where he received a master's degree from the University of Helsinki in organic chemistry. He worked in the Finnish paper industry from 1953 to 1957 and has since been employed by West Virginia Pulp & Paper Co.

Ralph Lau, a June graduate of the University of Wisconsin with a B.S. degree in chemistry, has been employed as a chemist trainee.

John B. Kahoun, who holds mechanical and electrical engineering degrees from Milwaukee School of Engineering, is now on the department staff as a designer.

Three personnel appointments at the Biron Division of Consolidated Water Power & Paper Co. have been announced by R. J. Mader, division manager.

Max Hughson has been appointed to the new position of technical manager. James Schad has been named to succeed Mr. Hughson as technical supervisor and John H. Barrette has been appointed assistant superintendent of yard and fiber production.

Mr. Hughson began his employment with the company at Biron Division in January, 1958, as technical supervisor. He was graduated from the University of Toronto in 1947 with a master's degree in chemical engineering. He was employed by Provincial Paper Co. as a technical control superintendent before joining the company.

Mr. Schad, a graduate of New York State College of Forestry, began his work with Consolidated in 1953 following summer employment in the company's laboratory. He was appointed project engineer at Biron Division in 1956 and has been assistant to the superintendent of paper machines there since 1957.

In his new position, Mr. Barrette will work under the direction of W. R. Vidal, superintendent of yard and fiber production. Mr. Barrette began his employment with the company in 1950 following graduation from the University of Wisconsin where he received a degree in chemical engineering. He has served as a chemist in the Technical Department and has been process engineer at Biron since 1958.

Promotion of three men at the Wisconsin Rapids Division of Consolidated Water Power & Paper Co. was announced today by L. W. Murtfeldt, division manager.

Jack Chinn has been appointed technical supervisor, succeeding James Schoettler who has accepted a position with another paper manufacturing firm. Leo Reiman will succeed Mr. Chinn as assistant paper machine superintendent. Donald Marks has been named assistant to the paper machine superintendent.

Mr. Chinn, a graduate of Cornell College, attended The Institute of Paper Chemistry before joining the company in 1954. Mr. Reiman began his employment with the company in 1933 and has been serving as enamel paper tour foreman. Mr. Marks, who has been with the company since 1935, has been employed as technical assistant in the Technical Department since 1957.

George Royan has been appointed to the newly-created position of plant superintendent of the Appleton Division of Consolidated Water Power & Paper Co., it has been announced by L. E. Smith, division manager. In his new capacity Mr. Royan will supervise plant operations and maintenance. Mr. Royan began his employment with Consolidated in 1946 and since 1955 has been Appleton plant engineer.

Hugh D. Burnie has been appointed coating department superintendent at Wisconsin Rapids Division of Consolidated Water Power & Paper Co., it was announced by L. W. Murtfeldt, Division Manager.

Mr. Burnie, who succeeds the late Mike Nilles, was graduated from Queens University, Kingston, Ont., with a degree in chemical engineering in 1951. He was employed for two years by Provincial Paper Co., Port Arthur, Ont., before enrolling at Western Michigan State College where he received a degree in paper technology in 1954. He joined the company during the same year and has served as assistant coating superintendent, mill chemist, and more recently as a project engineer in the Research and Development Department.

Beckett

William Beckett, president of the Beckett Paper Co., located at Hamilton, Ohio, and Donald S. Leslie, president of Hammermill Paper Co., with head offices at Erie, Pa., have announced that the holders of more than 80% of the common stock of The Beckett Paper Co. will accept an offer by Hammermill Paper Co. to issue up to 112,750 shares of Hammermill common stock in exchange for the common stock of The Beckett Paper Co.

The Beckett Paper Co., founded more than a century ago, has a present paper manufacturing capacity of approximately 30,000 tons per year which will be increased in July of this year when a major rebuild of a present paper machine will be completed.

C.I.P.

Roy L. Campbell, secretary of Canadian International Paper Co. for the past 28 years, retired June 26 after an association of 45 years with the pulp and paper industry.

Vernon E. Johnson, C.I.P. president, announced earlier that R. W. Becket, Q.C., vice-president and general counsel

Best wishes of Canadian International Paper Co. are tendered to Roy L. Campbell, left, retiring secretary, by president Vernon E. Johnson. Mr. Campbell received a silver tray from the board of directors and holds a testimonial scroll marking his long service with C.I.P. which he joined in 1925. He became secretary in 1931. His association with the pulp and paper industry dates back 45 years

for the company, will assume the additional duties of secretary.

Mr. Campbell graduated in arts and forestry from the University of Toronto in 1914, when he became editor of *Pulp and Paper Magazine of Canada.* Following two years service with the Canadian Manufacturers' Association, he joined The Riordon Pulp and Paper Co. in 1917. Mr. Campbell was with C.I.P. since 1925, when the company acquired Riordon. He became secretary in 1931.

In 1953, he was elected mayor of Westmount for a two-year term, having served as an alderman since 1949. He is a governor of Sir George Williams College.

Mr. Campbell was the 1958 recipient of the national distinguished professional service award from the Chartered Institute of Secretaries of Canada.

Mr. Becket, who is a director of a number of subsidiaries of C.I.P. and other companies, obtained his law degree from McGill University in 1934. He joined C.I.P. in 1950 and was named vice-president earlier this year.

K.V.P.

Robert D. Caine, vice-president of manufacturing, announces the appointment of Allen W. Krogel as plant manager for KVP's converting plant in Houston, Tex., and Glenn Quigg as manufacturing superintendent, effective July 1, 1959.

Mr. Krogel, in his new capacity, will be responsible for all manufacturing operations. Appointed as administrative assistant to the plant manager in August, 1957, Krogel was named acting plant manager in 1958.

Mr. Krogel joined KVP in March, 1953, as a general helper in the Wax Division at the company's Kalamazoo plant. After graduation from Western Michigan University (Kalamazoo) in June, 1956, he was named a supervisor in the Wax Division and then transferred a year later to the Printing Division as a staff assistant. Until his first appointment at the Houston plant, Krogel received additional experience in all phases of converting operations at the Kalamazoo plant.

Mr. Quigg joined KVP in June, 1920, as a helper in the Kalamazoo plant's Wax Print Shop. He was transferred as a supervisor to the Houston plant in October, 1938. With 39 years of KVP service at age 55, Quigg has the distinction of having more years of service for his age than any other KVP employee.

St. Regis

Rhinelander Paper Co., division of St. Regis Paper Co., announces the appointment of William A. Moggio as production manager for its Lake States Yeast Division, and John Greene as technical supervisor for the Yeast Department.

Mr. Moggio had been technical assistant to the division manager. He joined Rhinelander in 1958. A native of New Jersey, Mr. Moggio is a graduate of Rutgers University, with the degree of B.S. in chemistry. He also has an M.S. degree in Sanitary Science.

Mr. Greene joined Rhinelander in 1949 in the firm's Wet Laboratory. He was a paper tester, became a laboratory technician, and later was a chemist in the mill laboratory. In 1953 he was appointed chemist in the Yeast Plant. He attended the University of Wisconsin.

Richard C. Crain has been appointed technical director of Rhinelander Paper Co., division of St. Regis Paper Co. He is in charge of the research department, converting plant laboratory, the main plant control laboratory, quality control, coater mixing, and other related technical matters.

Rhinelander also announced the appointment of Francis Ratliff as research director and John Gaffney as manager of the Technical Service and Product Development Department.

Mr. Crain was research director of Rhinelander since 1954, when he joined the company. He had previously been general superintendent of Columbia River Paper Mills in Vancouver, Wash. Mr. Crain received his B.A. in chemistry and physics from Wooster College and his Ph.D. from The Institute of Paper Chemistry at Appleton, Wis.

Mr. Ratliff has been with Rhinelander's Research Department since 1957. He previously was research and technical director of the paper mill for Personal Products Corp. from 1951 until 1957. He is a graduate of Louisiana State University with a B.S. degree in chemical engineering and received his Ph.D. degree from The Institute of Paper Chemistry.

Mr. Gaffney came to Rhinelander in 1940 as a paper chemist in the laboratory. In 1952 he became assistant technical director and was named technical control superintendent in 1954. He is a graduate of Northeastern University in Boston, Mass.

Continental Can

Russell D. Scribner has been appointed general manager, Central Region, for the Boxboard & Folding Carton Division of Continental Can Co., it was announced by William H. Caddoo, division vice-president.

Formerly manager of the division's Elkhart, Ind., facility, Mr. Scribner will now be in charge of all sales and production activities in the Central Region. The territory includes sales offices at Detroit and Grand Rapids, Mich.; Cleveland, Cincinnati, and Middletown, Ohio; Elkhart, Indianapolis, and Evansville, Ind.; Chicago, Ill.; St. Paul, Minn.; St. Louis and Kansas City, Mo.; Dallas, Tex.; and Pittsburgh, Pa. It also takes in plants at Chicago, Ill.; Middletown, Ohio; and Elkhart, Ind.

Mr. Scribner replaces Charles A. Colbert, who has resigned from the company to form his own business. Headquarters for Mr. Scribner will be in Chicago.

George Oechsle takes over as Elkhart plant manager. He was formerly assistant plant manager at this location and, prior to that, mill superintendent at the division's Piermont, N. Y., plant.

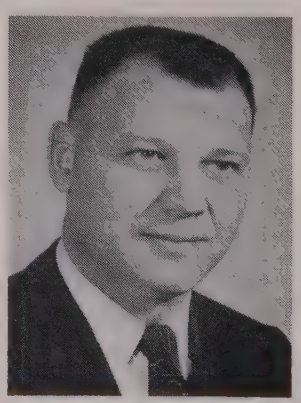
Gail Posson, previously assistant plant manager at the Thames River, Conn., plant of Continental Can's Boxboard and Folding Carton Division, has been appointed plant manager at this location, it was announced by O. M. Miller, division general manager of the Eastern Region. He replaces John H. Fettinger who is retiring after having served with the Robert Gair organization for the past 47 years.

Mr. Posson started with Gair in May, 1951, as an industrial engineer at its Chicago plant and moved to the Thames River plant position in October, 1954.

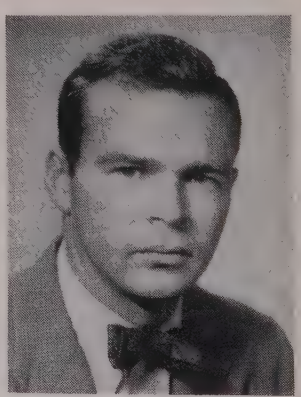
O-I

E. J. Kiddie, production manager at Owens-Illinois Glass Co.'s Paper Products Division plant at Jacksonville, has been named assistant general manager there.

Succeeding Mr. Kiddie as production manager will be Peter M. Coy, for the past two years supervisor of corrugating,



E. J. Kiddie, Owens-Illinois Glass Co.



P. M. Coy, Owens-Illinois Glass Co.

carton assembly, and statistical quality control for the Libbey Glass Division of O-I.

George R. Zaloudek, staff engineer for the Owens-Illinois Glass Co. Mill Division, has been named division engineer.

His appointment was announced by Fred B. Schelhorn, vice-president in charge of manufacturing and research for the Mill Division. Mr. Zaloudek succeeds Glenn Ralston.

A native of Medina, Wash., Mr. Zaloudek was assistant plant engineer and later plant engineer at the company's Valdosta, Ga., paper mill. He was transferred to the company's general headquarters in Toledo, Ohio, as staff engineer last year.

Before joining O-I he served in engineering capacities with Rayonier, Inc., Masonite Corp., and the Beloit Iron Works.

Butler

Paul Butler, president and general manager of the Butler Co., Chicago, announces the election of Phillip L. Knapp as a vice-president. The Butler Co. controls the interest of the Butler Paper Corporations and their 35 divisions, Butler Aviation, Butler Research, and the Oakbrook Realty Division. Mr. Knapp will be primarily associated with paper. He was formerly associated with Bulkley, Dunton & Co. of New York and the S. D. Warren Co. of Cumberland Mills, Me.

Diamond Gardner

Diamond Gardner Corp. has announced three major promotions.

William H. Aiken has been appointed director of research and development for the corporation. His office will remain in Middletown, but he will be engaged entirely in corporate research projects.

Mr. Aiken, who hails from Salado, Tex., received his B.S. degree from Texas A&M. He has a Ph.D. degree from The Institute of Paper Chemistry, Appleton, Wis.

He joined Gardner in 1952 as technical director. In 1958 he was promoted to director of research and development, paperboard products.

Richard D. Williams has been named director of industrial and public relations. In his new post, he becomes a member of The Gardner Division's operations committee.

Raised in Fairfield, Ia., Mr. Williams attended the University of Virginia, received his bachelor's degree from Ohio Wesleyan, and his master's degree from Northwestern.

He joined Gardner in 1949 as a personnel clerk. That same year he was named administrative assistant, industrial relations. In 1950 he was promoted to assistant to the supervisor of industrial relations, Middletown.

Mr. Williams became supervisor of wage and salary administration in 1953, and two years later was promoted to coordinator of personnel development. In 1956 he was appointed supervisor of industrial relations for the company's Lockland operations. He was promoted to director of industrial relations for The Gardner Division in 1957.

R. D. Williams, Diamond Gardner Corp.

T. G. Zentner, Diamond Gardner Corp.

Thomas G. Zentner has been appointed director of research and development, the Gardner Division.

A native of Rowena, Tex., Mr. Zentner was graduated from Texas A&M. He received his master's and doctor's degrees from The Institute of Paper Chemistry.

Mr. Zentner's first job with Gardner was as a mill technician in 1952. A year later he was promoted to technical supervisor in the Lockland carton plant. He became assistant technical director, carton plant development, in 1956.

Inland

James O. Harris has been appointed vice-president of Inland Container Corp., Indianapolis, Ind.

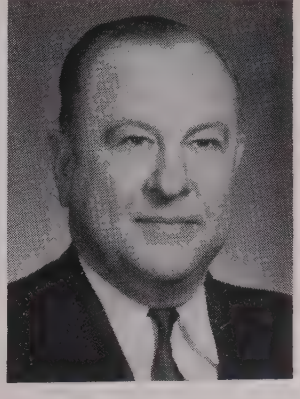
Mr. Harris is a graduate of the School of Business Administration of Indiana University. He served four years in the Army and was discharged with the rank of lieutenant colonel. He has been active at Inland the past several years in purchasing, quality control, and various phases of mill operations. He will continue his present work in the mill division, including roll stock procurement, quality control, sales, and planning.

C. Wayne Smith has also been appointed vice-president of Inland Container Corp.

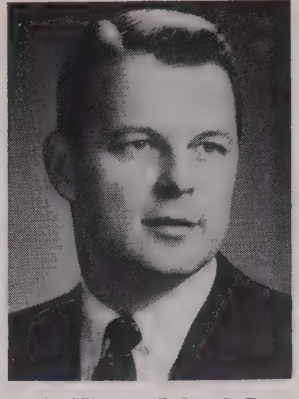
Mr. Smith is a graduate of the School of Engineering of the University of Arkansas and has been connected with the kraft pulp and paper mill operations in the South for over 20 years. His experience has covered all phases of kraft mill operations, including engineering and production management.

He will continue his present responsibilities of working on Inland's mill programs and operations in the South. Mr. Smith is located at the Inland Container Corp. plant at Krannert Station, Rome, Ga.

P. L. Knapp, Butler Co.



W. H. Aiken, Diamond Gardner Corp.



J. O. Harris, Inland Container Corp.

C. W. Smith, Inland Container Corp.

FOREST PRODUCTS LAB

J. Alfred Hall will retire August 31 as director of the United States Forest Products Laboratory, Madison Wis., and will be succeeded by Edward G. Locke, chief of the world-famed institution's division of wood chemistry for the past eight years.

The retiring director said he will take up residence in Portland, Ore., where he will do consulting work for industrial concerns in the forest products field.

Mr. "Locke," he said, "is eminently qualified to take over as director. He has built up a strong research program as chief of the division of wood chemistry and possesses an excellent background knowledge of the problems of the wood-using industries as well as the needs for basic research."

Mr. Hall gave as his principal reason for giving up his post at this time the fact that "the laboratory is in better position, financially and otherwise, now than it has been in some years."

"We have grown some competent younger men here, who I am sure will take over capably. I look forward to watching the laboratory grow to even greater stature in the years to come. There are both great opportunities and great needs for its continued work on an expanded scale."

In a facetious vein, he added that "duck-hunting on the Pacific flyway has become so much better, and the Mississippi flyway so poor, that I feel a change of climate is indicated."

The laboratory is maintained by the Forest Service, United States Department of Agriculture, in cooperation with the University of Wisconsin. Its field of operations covers all aspects of timber utilized, from harvesting and milling to construction, pulp and paper, engineering, preservation, packaging, seasoning, gluing and laminating, chemical processing, and related fields.

Mr. Hall's directorship of the laboratory has been highlighted by his participation in a presidential commission task group in 1957 that recommended greatly increased research on wood to utilize effectively much low-quality timber, as well as industrial wastes.

The commission report included the recommendations of his task group, and has been submitted to Congress.

He retires as only the fifth director in the nearly half century that the laboratory has been in existence. He began his Forest Service career in 1930 as a biochemist on the Laboratory staff, specializing in research on the resin production of southern pines. In 1937 he was appointed assistant director of the California (now Pacific Southwest) Forest Experiment Station at Berkeley.

Since then he has been director of the Central States Forest Experiment Station at Columbus, a specialist on research problems with the Forest Service headquarters staff at Washington, D. C., during the war and, for six years before coming back to the laboratory as its director, served as director of the Pacific Northwest Forest Experiment Station in Portland, Ore.

BOLTON

John W. Bolton & Sons, Inc., machine knife manufacturers of Lawrence, Mass., has just announced a new high alloy paper knife known as Boltoloy. Recently developed, fully tested and proved techniques of manufacturing make possible this new knife, which combines quality and a competitive price.

Introduction of the Boltoloy knives follows a pattern established by this machine knife manufacturer of carrying on a constant program of metallurgical research and development to keep pace with the requirements of the paper and graphic arts industries. In 1946 Bolton introduced substantial improvements and refinements on existing grades of alloys. Two years later the company introduced the first high-speed paper knife to the industry.

John W. Bolton & Sons, Inc. of Lawrence, Mass., effects efficiencies in servicing the needs of the pulp and paper industry with replacement parts for jordans and beaters and with knives by maintaining a huge inventory of special metals for immediate processing to the finished product. This entire stock is produced at the mills according to exact specifications for size, shape, analysis, and alloy composition.

Considered the largest single metals inventory carried by any manufacturer of stock preparation equipment, it consists of more than 2000 tons of special steels for papermaking. Made up of hot rolled or extruded bars and plates, the inventory includes high speed steel, tool steel, alloy steel, Bolton special stainless, phosphor bronze, and other specification alloys.

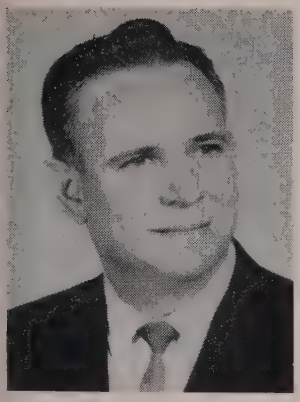
A separate steel storage warehouse is used to house these raw materials. Overhead cranes, fork trucks, and other materials handling equipment contribute to its efficient operation, together with convenient receiving and shipping facilities.

The first step in processing orders is completed at the warehouse, where the steel is rough cut to specifications, palletized, and transported by truck the short distance to Bolton's heat treating furnaces and machine rooms for finish processing and testing.

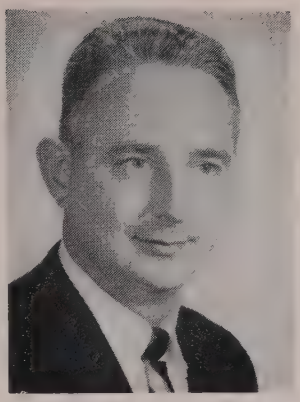
All steel inventoried is properly indexed according to type, size, and metallurgical content; closely controlled to assure a constant and adequate supply. This expedites the processing and shipping of orders for stock preparation replacement parts and protects paper mill clients in the event of emergency breakdown, and is an important deterrent to any shortage of raw materials.

New section (foreground) added to its Willow Grove (Pa.) plant by the Moreland Corp. enlarges the firms facilities by 30%. Moreland is the largest exclusive manufacturer of printing and industrial rollers in the United States. The addition was planned and constructed by William F. Lotz Inc. (Phila.).

Bolton-Emerson's steel storage warehouse, showing a small part of the inventory



J. H. Reid, John W. Balton & Sons, Inc.



J. L. Sigler, John W. Bolton & Sons, Inc.

Jack H. Reid has been appointed sales engineer by John W. Bolton & Sons, Inc. and The Emerson Manufacturing Co. division. He will represent the manufacturer of machine knives and pulp and paper machinery and equipment in mills in the South.

John L. Sigler has been made regional manager of the Southern Sales Region of John W. Bolton & Sons, Inc. and The Emerson Manufacturing Co. Division of Lawrence, Mass., according to an announcement made by H. M. Reiniger, vice-president in charge of sales.

G.E.

A new, eight-page catalog highlighting the major General Electric silicone products and their uses is now available from the Silicone Products Department, General Electric Co., Waterford, N. Y.

Designated as CDS-129A, this illustrated publication lists additional specialized literature covering product and application information as well as major G.E. silicone products.

Mallinckrodt Nuclear

Frank Zeitlin has been named assistant vice-president of the Mallinckrodt Nuclear Corp. effective July 1, 1959. The announcement was made by Frederick M. Belmore, vice-president and general manager of Mallinckrodt Nuclear.

As assistant vice-president, Mr. Zeitlin will participate in general management of the Nuclear Corp.

B&W

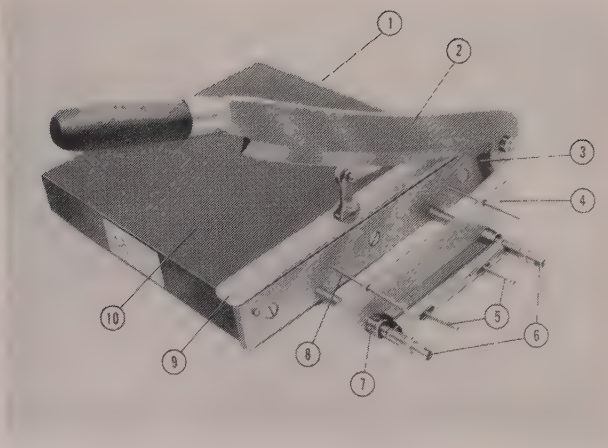
Robert A. Barr has been appointed general manager of The Babcock & Wilcox Co.'s Refractories Division, it has been announced by J. E. Brinckerhoff, vice-president in charge of the division.

Engineers, purchasing agents, and others responsible for the procurement of welding fittings and flanges will be interested in the information contained in a new booklet released by the Tubular Products division of The Babcock & Wilcox Co. This 12-page booklet, known as FB-78, is a guide to material selection of carbon, alloy, and stainless steel welding fittings and flanges. Copies of FB-78 are available without charge from the sales office of the company at Beaver Falls, Pa.

T.M.I.

Many improvements have been included in the new TMI precision adjustable strip cutter. The heavy and rugged high precision TMI test specimen cutter, which has been available for many years has been completely redesigned to speed up and facilitate work in the laboratory.

The release handle (5) adjusts widths with a flick of the finger. The adjustment is instantaneous. The guide bar (4) slides on precision ball bearing bushings (8) and is accurately and rigidly locked into position. The sturdy



New TMI precision adjustable strip cutter

polished hard wood is approximately two inches thick. An accurate metal scale (1) is mounted on the base. A self acting hold down bar (9) automatically clamps the sample and prevents slippage. The cutting plate and bed knife is custom manufactured and will last a lifetime. It is of the heaviest and most precise design available. The manufacturer states these improvements will further aid the technician by facilitating and speeding sample preparation.

For complete details write Testing Machines, Inc., 72 Jericho Turnpike, Mineola, L. I., N. Y.

Ross Engineering

Effective May 11, 1959, the new headquarters address of the J. O. Ross Engineering Division of the Midland-Ross Corp. became 730 Third Ave., New York 17, N. Y. Ross occupies the ninth floor of the modern new air conditioned General Telephone building at this location.

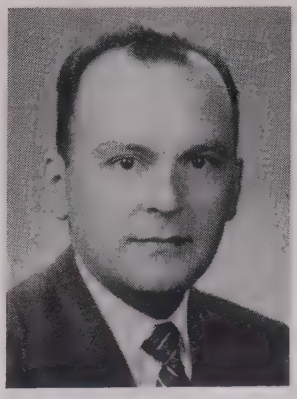
Ross Engineering designs, manufactures, and installs air processing equipment for use in heating, drying, and curing operations in such industries as paper, textile, automotive, paint finishing, plastics, and foundry.

The move was necessitated by an approximate 30% expansion of the Ross staff during the nine years at the previous location. The new location has roughly 5000 sq. ft. more floor space than the old one, and also provides for an additional 4000 sq. ft. as needed.

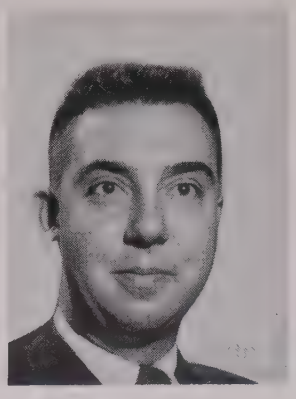
Staley

Three appointments in the A. E. Staley Manufacturing Company's industrial sales organization were announced by N. K. Hammer, field sales manager, effective June 15.

John P. Bolas becomes assistant manager in Staley's Philadelphia branch office, promoted from senior sales representative in the Chicago branch office.



J. P. Bolas, A. E. Staley Mfg. Co.



J. W. Lusk, Jr., A. E. Staley Mfg. Co.

Robert E. Smith becomes sales representative in the Chicago area, transferred from the company's Boston branch office to succeed Bolas.

John W. Lusk, Jr., takes on new territorial responsibilities in the Boston office, moving from his industrial sales assignment in Philadelphia.

Clinton

Appointment of Robert H. Boegel as assistant sales manager, primary products, for Clinton Corn Processing Co., Clinton, Iowa, has been announced by H. A. Bendixen, vice-president and general sales manager.

Bauer

A new 24-in. pressure-type single revolving disk refiner with 50 tons per day pulp capacity has been developed by The Bauer Bros. Co., 1715 Sheridan Ave., Springfield, Ohio.

The new No. 444-24 in. Pump-Through refiner is designed primarily for small and medium sized mills. The unit provides excellent pulp quality and can be used for a wide range of stock preparation and special fiberizing applications. It offers high capacity at relatively low power consumption and operating costs.

This small Pump-Through refiner can be supplied with standard manual, automatic, or remote controls for quick control of plate clearance to compensate for the type of stock desired and to assure maximum uniformity in refining.

David M. Shapleigh has been appointed Eastern Division Manager by The Bauer Bros. Co., Springfield, Ohio, manufacturers of machinery for the pulp and paper industry.

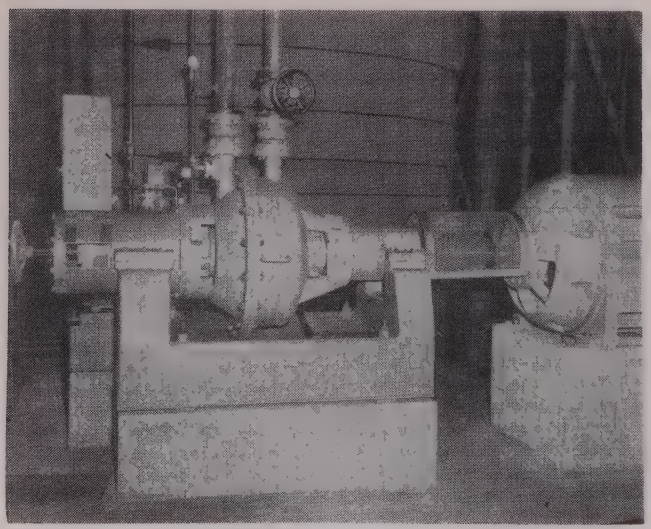
Mr. Shapleigh will personally serve accounts in New York City, New Jersey, Pennsylvania, Delaware, and Maryland. He will also assist other Bauer representatives in the Eastern United States.

United States pat. 2,878,934 with an effective filing date January, 1951, has been issued to Howard Smith Paper Mills, Ltd., Cornwall, Ont., naming George H. Tomlinson II inventor. The Bauer Bros. Co. of Springfield, Ohio, is exclusive licensee of patent.

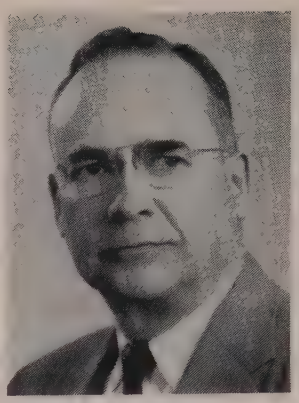
The new patent covers application of vacuum to the reject discharge of centrifugal cleaners. Bauer applies vacuum to Centri·Cleaners at the reject orifice for many uses such as stock cleaning ahead of paper machines.

Howard Smith Paper Mills' research organization headed by George H. Tomlinson II, director of research did the original and fundamental development work with 12 in. diameter Centri·Cleaners in 1950 and has been credited with the original invention of all vacuum applications for cyclonic rejects discharged from such vessels.

This invention is also covered in Canada and foreign countries by similar applications.



Installation of new Bauer No. 444-24-in. pump-through refiner



D. M. Shapleigh, The Bauer Bros. Co.

D. B. Wicker, Huyck Felt Co.

Huyck Felt

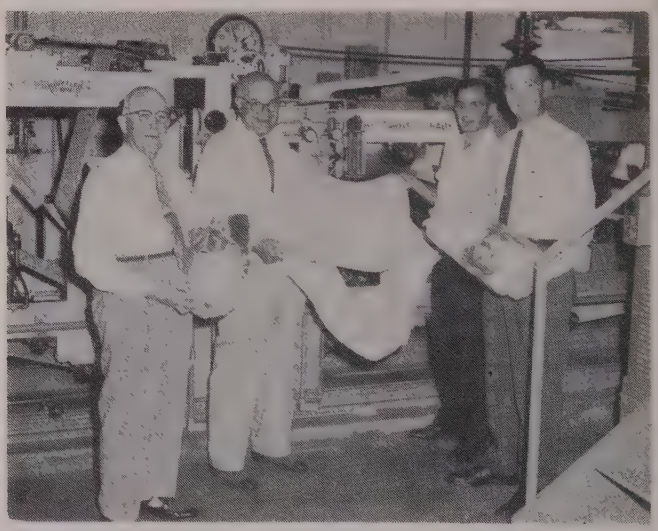
Huyck Felt Co., Rensselaer, N. Y., and Aliceville, Ala., announces the appointment of Dan B. Wicker to vice-president and director of research and development.

Since joining Huyck, he has pioneered in applying scientific instrumentation to the manufacture, testing, and evaluation of paper machine felts. His work with the beta ray gage has made it possible to measure felt performance quantitatively on the paper machine so that felts may be custom engineered to meet specific application requirements.

Dow

The Dow Badische Chemical Co. has announced plans to produce acrylic acid and methyl, ethyl, butyl, and other acrylic esters at a plant under construction near Freeport, Tex.

Production is expected to begin next January, following



James Clark, southeastern sales representative, Huyck Felt Co., Rensselaer, N. Y., and Aliceville, Ala., (right,) is seen presenting one of two sets of felts donated recently by his company to clothe an experimental paper machine operated by student papermakers in the college's Department of Pulp and Paper Technology. Members of the college's staff with Mr. Clark are: C. E. Libby, professor and head of the Department of Pulp and Paper Technology; H. D. Cook and R. G. Hitchings, assistant professors

completion of the plant in December. Construction has been in progress for the past eight months at a site adjacent to The Dow Chemical Co.'s Texas Division.

The company, capitalized at $6,000,000, is owned jointly by Dow and BASF Overzee, N. V., a subsidiary of Badische Anilin- & Soda-Fabrik AG of Ludwigshafen a. Rhein, Germany.

The acrylic acid will be manufactured as a 94% technical grade by a direct process developed by Badische and believed new to the United States chemical scene.

Acrylic esters will be produced by esterification with methyl, ethyl, butyl, and other alcohols.

Production will be sold through The Dow Chemical Co. Sample quantities are available through the Dow Plastics Sales Department, Midland, Mich.

Chain Belt

A new 72-page bulletin, No. 5980, on belt conveyor idlers and conveyor pulleys has been published by Chain Belt Co., Milwaukee.

A new 12-page bulletin, No. 5983, on Rex water knives for any type of washing, cleaning, descaling, and cooling operation has just been published by Chain Belt Co., Milwaukee, Wis. (Water knives were formerly marketed by the company as "flat spray nozzles.")

For a copy of these bulletins, contact the nearest Chain Belt distributor or district office, or write direct to Chain Belt Co., Sales Promotion Department, Milwaukee 1, Wis.

B-C

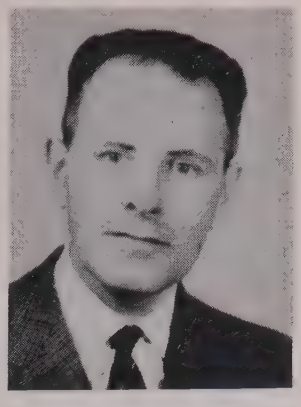
The appointment of Richard W. Phelps as general manager of the Dilts Division, Fulton, N. Y., has been announced by Frank T. Peterson, president of the company. Mr. Phelps will be responsible for management of all the activities of the Dilts Division, which manufactures the Black-Clawson line of converting machinery for the paper and plastics industries.

To handle its business in the Republic of Italy more efficiently, The Black-Clawson Co. has established Black-Clawson Italia, it was announced by Frank Peterson, president of the international manufacturer of pulp and paper mill equipment.

Black-Clawson Italia, an Italian corporation, is located at Via Meravigli 7 in Milano and is under the management of Virginio Zani. Mr. Zani is a chemical engineer with wide experience in the pulp and paper industry throughout Italy. He has also done work in South America on the pulping of agricultural residues including sugar cane bagasse.

Equipment supplied by Black-Clawson Italia includes pulp mill equipment, stock preparation units, paper and board machines, and paper and plastics converting machinery, produced either in the Black-Clawson International works in England or in the four plants of Black-Clawson in the United States. In addition, certain Hydrafiners, jordans and Hydrapulpers are manufactured under license in Italy by Figil di Carcano Gerolamo in Masilianico and sold by Black-Clawson Italia.

R. W. Phelps, The Black-Clauson Co.



Virginio Zani, Black-Clauson Italia

Cyanamid

R. E. Leach has been appointed manager of the Marietta, Ohio, plant of American Cyanamid Co., and A. C. Fennimore has been named manager of the company's Willow Island, W. Va., plant, it was announced by Wm. H. Bowman, general manager of the Organic Chemicals Division.

J. W. Dykes, who has managed both locations for over 10 years, has been named manufacturing management consultant to the division. He expects to retire from Cyanamid later this year, after 41 years of service with the company.

"For several years," Mr. Bowman said, "the Marietta and Willow Island operations have been managed jointly by one staff, which for the most part has had its headquarters at Willow Island. Steady, continued growth in the business of our Marietta plant has made it necessary for us to establish separate plant management at this location in order to keep pace with the demand for Marietta products."

The Marietta plant makes brightening agents, chemicals, dyes, pharmaceuticals, and ultraviolet absorbers. Willow Island makes inorganic pigments, melamine, petroleum catalysts, pharmaceuticals, aniline, and miscellaneous chemicals.

F.M.C.

Food Machinery and Chemical Corp. and Elfa, Ltd., Electrochemical Works, Aarau, Switzerland, announce the expansion of Elfa's hydrogen peroxide facilities. The new facilities incorporate the designs and techniques of the electrolytic process which FMC's Becco Chemical Division developed and uses at its plants in Buffalo, N. Y., and Vancouver, Wash.

Elfa is one of the world's first producers of hydrogen peroxide by the electrolytic method. The latest plant expansion was accomplished to meet growing demands in the textile industry and for other new chemical uses.

Lindsay

Hugh P. Quinn has joined the technical services staff of The Lindsay Wire Weaving Co. of Cleveland. He has acted in a service capacity to paper mills for more than 20 years.

H. P. Quinn, Lindsay Wire Weaving Co.

Miehle-Goss-Dexter

J. E. Clark, sales representative for the Lawson Co., Division of Miehle-Goss-Dexter, Inc., will also represent MGD's other bindery division, The Dexter Co., according to a recent announcement by Carlton Mellick, director of sales for the two divisions. The move is part of a continuing program designed to recognize the more specialized needs of the trade.

Mr. Clark's territory includes upper New York, Western Pennsylvania, and Northern West Virginia. He will continue to have his headquarters at 182 State St., Rochester, N. Y., telephone HAmilton 6-5029.

Borden's

An eight-page directory of its various polymer products and their specific properties as well as uses is being made available by the Borden Chemical Co. to the paper, paint, textile, and adhesives industries. Copies may be obtained from the Borden Chemical Co., Polyco-Monomer Department, 350 Madison Ave., New York 17, N. Y.

PUSEY & JONES

The Pusey and Jones Corp., Wilmington, Del., has been awarded a contract to build a 172-in. fourdrinier, kraft machine for the Fibreboard Paper-Products Corp. The contract was awarded by the Bechtel Corp., San Francisco, contractors and engineers of the new paperboard mill.

The new machine will be installed at a Fibreboard Paper Products Corp. mill in San Joaquin, Calif.

Pusey and Jones is one of the country's oldest firms specializing in the manufacture of papermaking machinery. The company was founded in 1848, at its present location on the Christina River in Wilmington, Del. It has specialized in the development of high-speed machines.

PERKINS-GOODWIN

Louis Calder, Jr., president of Perkins-Goodwin Co., international pulp and paper marketing-management organization, has announced that Richard T. Trelfa, who joined the Perkins-Goodwin firm on June 1, 1958, as director of technical services, has been elected a vice-president and director.

WARREN PUMPS

Warren Pumps, Inc., Warren, Mass., has appointed John H. Marvin Co., Inc., industrial sales representative in Washington and Oregon.

Marvin's address is 422 1st Ave., West, Seattle 99, Wash., telephone AT 4-0331. A branch office is located at 6106 N. E. 18th Ave., Portland, Ore., telephone AT 4-7913.

Ralph L. Dyer, Warren's former industrial sales representative, will continue to handle Federal and Marine sales in the Pacific Northwest.

Warren manufactures a complete line of centrifugal, reciprocating, screw, and gear pumps for industry.

CAMERON

Cameron Machine Co., Dover, N. J., has formed a subsidiary company to be known as Cameron Leasing, Inc.

The new company was set up to handle the leasing of complete installations of slitting and roll winding machines and roll production equipment.

According to Cameron officials, the greatly increased interest in leasing of equipment could be served best by a separate company. Cameron inaugurated their leasing program several months ago, providing a method for companies in the industries they serve to acquire the use of modern equipment with no capital investment.

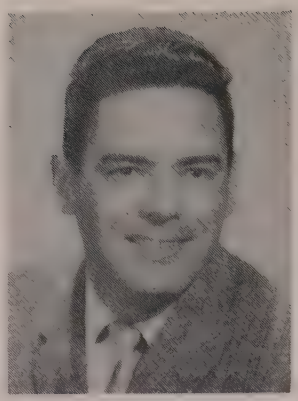
The new company will be located at the same address of the parent company.

MINERALS & CHEMICALS

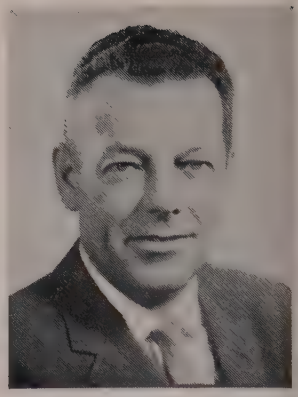
The appointment of W. E. Welliver and Thomas C. Morganstern as regional technical sales representatives to the paper industry is announced by G. A. Hale, manager of paper clay sales, Mineral & Chemicals Corp. of America. These appointments will further extend the company's technical service in the application of Edgar coating and filling clays.

W. E. Welliver, Minerals & Chemicals Corp. of America

T. C. Morganstern, Minerals & Chemicals Corp. of America



H. E. Keene, Improved Machinery, Inc.



H. L. Smith, Jr., Bowen Corp.

IMPCO

Improved Machinery Inc., Nashua, N. H., announces the appointment of Harold E. Keene as sales representative for Tennessee, Southwestern North Carolina, North and Central Georgia, North and Central Alabama, and Northern Mississippi.

BOWEN

The Bowen Corp. of Cambridge, Mass., announces the appointment of Hiram Leroy Smith, Jr., of Winchester, Mass., as chief engineer in the Chemical Division.

HOOKER

"Hooker Type S Cells," Bulletin 20-A, is a completely revised edition of former Bulletin 20, and is available without charge from Hooker Chemical Corp., Niagara Falls, N. Y.

ORR FELT

W. R. "Dick" Spencer has been appointed sales representative for the South Central territory of Orr Felt & Blanket Co. which was made vacant by the untimely death of George Witham.

CHEMIPULP

Chemipulp Process Inc., Watertown, N. Y., announces the appointment of A. E. Theisen as president to succeed the late Albert D. Merrill. Mr. Theisen was also appointed secretary of the company. Jack Grant is the vice-president and treasurer and B. E. Gruntorad assistant treasurer and assistant secretary.

Mr. Grant continues as president and treasurer of Chemipulp Process Ltd., Kingston, Ont., and Mr. Theisen retains the position of vice-president and secretary of the Canadian affiliate.

FULLER

The role of pneumatic conveying equipment in the pulp and paper industry is discussed in a 16-page bulletin recently issued by Fuller Co., designers and manufacturers of pneumatic conveying systems and components. For copies, write for Bulletin FF-26-2, "Fuller Equipment for the Pulp and Paper Industry," Fuller Co., Catasauqua, Pa.

NEW JERSEY ZINC

The New Jersey Zinc Co. has announced a further extension of its representation in the zinc and titanium pigment consuming fields, with the appointment of the following members to the sales staff in the Middle West and West Coast areas.

Harold R. Frasure will take up his duties at Cincinnati and will cover the Columbus, Dayton, and Indianapolis areas as well.

Stanley E. Moore joins the Chicago sales office and his territory will include the Minneapolis St. Paul area.

John B. McCarthy will make his headquarters at the Los Angeles sales office.

Walter E. Menhinick, who has been a member of the Chicago office, is transferred to St. Louis. He will also cover the Kansas City and Louisville areas.

NOPCO

The appointment of John E. Ward as resident manager of Nopco Chimie S. A., Firbourg, Switzerland, has been announced by E. A. Robinson, vice-president in charge of laboratory research and development and foreign sales for the Industrial Division. At the same time Mr. Robinson announced the appointment of A. Howard Stuewe, who replaces Mr. Ward as technical manager of Nopco's Foreign Department-Industrial.

OBITUARIES

Albert Guy Durgin

Albert Guy Durgin, representative of the Pulp and Paper Foundation, University of Maine, died suddenly May 7, 1959.

Mr. Durgin was born in Orono, Me., and graduated from the University of Maine in 1908 with a B. S. and in 1909 with an M. S. In 1914 he became the first instructor in pulp technology at the University. From 1916–19 he was chemist, then chief of the Paper Section at the U. S. Bureau of Standards. Mr. Durgin's activities included: superintendent of operations-research, Spanish River Pulp & Paper Co., 1919–26; engineer, Industrial Division, Canadian Bank of Commerce, 1926–27; superintendent, Spruce Falls Power & Paper Co., Ltd., 1927–33; superintendent of control, Brompton Div., St. Lawrence Corp., various capacities from consultant to general superintendent to mill manager, 1933–55; and traveling representative of the University of Maine Pulp and Paper Foundation from 1955 until his death.

A. Guy Durgin

Guy Durgin was very active in TAPPI, becoming a member in 1917, and in the Technical Section, Canadian Pulp and Paper Association. He was a Registered Professional Engineer, Ontario, and a member of the Canadian Institute of Chemistry.

Albert D. Merrill

Albert D. Merrill, president of Chemipulp Process, Inc., Watertown, N. Y., died on June 7, 1959.

Mr. Merrill was born in Burke, N. Y., on June 25, 1885, and graduated from Clarkson College of Technology in 1913 as a civil engineer.

In 1915 he jointed the engineering staff of St. Regis Paper Co., in Deferiet, N. Y., as an assistant engineer for general mill maintenance. In 1916 he became chief engineer for the Stebbins Engineering & Manufacturing Co.

In 1927, with Thomas L. Dunbar and A. F. Richter, Mr. Merrill formed Chemipulp Process, Inc., which was established to perfect new operating methods to increase yield and reduce production costs in the chemical pulp field. Mr. Merrill succeeded Mr. Dunbar as president in 1946, at which time he also became president of Chemipulp Process, Ltd., now of Kingston, Ontario.

Mr. Merrill held a total of 18 patents relating to chemical pulp and to pulp mill equipment.

Mr. Merrill became a member of the Technical Association of the Pulp and Paper Industry in 1926.

Lewis Stuart Reid

Lewis S. Reid, retired general purchasing agent for the Metropolitan Life Insurance Co., died on July 16, 1959, in Overlook Hospital, Summit, N. J., after a long illness.

Mr. Reid was born in Toronto, Canada on July 13, 1898, and graduated from Yale Sheffield Engineering School in 1919.

Prior to joining the Metropolitan Life Insurance Co. in 1936 as a laboratory technician, Mr. Reid was employed as a metallurgical engineer by Doehler Die Co., Magnetic Analysis Co., and Lucius Pitkin, Inc. He had also been an editor for *Aviation Engineering* Magazine and *Metals and Alloys* magazine.

In World War II he worked in Washington for the War Production Board and in 1952 served with the General Services Administration. In 1958 he received the American Society for Testing Materials Award of Merit.

He is survived by his widow, Mrs. Helen Hecht Reid and two sons, Charles L. Reid and Robert I. Reid.

Mr. Reid became a member of the Technical Association of the Pulp and Paper Industry in 1936 and took an active part in the work of the Testing Division.

Haskell Johnson Pedicord

Haskell J. Pedicord, Associate Director of Product Development of the Paper Products Division of Procter & Gamble Co., Cincinnati, Ohio, died following a brain tumor operation on June 20, 1959.

Mr. Pedicord was born in Baltimore, Md., on Jan. 14, 1922, and graduated as a chemical engineer from Johns Hopkins University in 1943.

Mr. Pedicord was appointed Associate Director at the time the Charmin Paper Mills were acquired by P. & G.

Following graduation Mr. Pedicord served, during World War II, as Lieutenant, Junior Grade, in the Navy. After the war he obtained a master's degree in chemical engineering from Columbia University just before joining the Procter & Gamble Co. in 1947.

H. J. Pedicord

He is survived by his widow, Carolyn Pedicord, and three children, Carolyn, Thomas, and Haskell.

He became a member of the Technical Association of the Pulp and Paper Industry in 1947.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Steam and Power Committee

The Steam and Power Committee's annual spring meeting was held at the Bismarck Hotel in Chicago on March 30, 1959. A total of 17 attended the meeting.

Members present were:

F. H. Coldwell
E. H. Donley
H. R. Emery
G. B. Gregg
W. H. Hall
J. G. Hoad
J. E. Hoeft
R. V. Knapp
L. Limon
N. H. Mailhos
P. L. Nelson
C. R. Podas
W. B. Wilson
G. L. Yeakel
W. H. Zieseniss

H. O. Teeple represented TAPPI Headquarters and R. A. Kennedy was a guest.

Our committee's 26 members include two who have joined us this year:

L. Limon
J. O. Starkweather

SUBCOMMITTEE REPORTS

Data Sheets (Proj. 684)

P. L. Nelson reported that his committee had reviewed data sheets assigned to the Steam and Power Committee and voided Data Sheet 117 entitled "Suggestions for Steam Plant Operation."

Based on the Data Sheets Session at the annual TAPPI meeting in February, there is still much to be desired from the standpoint of number and quality of data sheets being produced by all committees.

In addition to general data sheets on the production of steam and power, Mr. Nelson outlined his desire for a number of guide specifications which should permit purchasers to get comparable quotes on equipment. Typical of the subjects he has in mind are:

Water tube package boilers
Mechanical steam turbines
Boiler feedpumps
Combustion control
Spray type deaerators

Paper Mill Power Plants (Proj. 681)

E. H. Donley reported that, after some delays, his committee's report on "New Steam and Power Equipment for United States Paper Mills, 1957" was published in the December, 1958, issue of *Tappi*.

Mr. Donley raised the question as to whether or not the data could be presented in a form more useful to the readers. It is recognized that there is now a problem in knowing what year to start tabulating a job and when to stop tabulating the same job.

The committee moved that the tabulation be broken into two sections and suggested they be labeled: (1) Before Operation and (2) After Operation.

E. H. Donley and H. O. Teeple will also attempt to get the report published in a specific issue of *Tappi* each year so the readers can know just when to expect this data each year.

Progress in Nuclear Power (Proj. 726)

H. B. Wallace was not present to report for his subcommittee. The committee expressed a continued interest in having an annual "Status Report" from this committee.

The Martin Co. and possible other manufacturers continue to promote the use of nuclear steam generation in the paper industry. The consensus of most attending our committee meeting was that nuclear steam generation would not be economic for the U. S. paper industry soon. Mr. Magee and Mr. Wright may have something to say on this subject in their "Progress Report on Atomic Power" at the Steam and Power Committee's Pittsburgh program.

Steam & Power Consumption (Proj. 683)

J. G. Hoad reported that subcommittee members had provided flow sheets, questionnaires, etc. for review. The data in hand are to be reviewed and consolidated as a basis for a mill questionnaire. After the questionnaire is drafted, it is to be checked with subcommittee members and selected mill people for clarity and adequacy. The final questionnaire can then be mailed to the industry for reply.

By determining heat and power balances for different kinds of products, this committee's work should be very useful in planning new mills and mill expansions. It should also assist in evaluating the effect of superimposing new pulping methods on an existing mill. One member mentioned how a change from kraft to neutral sulphite upset mill heat balance.

Training of Power Plant Engineers (Proj. 682)

T. F. Woodward was not present to report. He is preparing a comprehensive bibliography of literature available on training. He is also arranging a panel presentation for the 1960 meeting in Jacksonville.

As voted at our Portland meeting, active work of this subcommittee will be terminated when the above work is completed at the time of the 1960 Jacksonville meeting.

Question and Answer

J. E. Mailhos was not present. From correspondence, however, it is apparent that the Steam and Power Committee members have not done a lot to help.

Why not send a few questions and answers for his use now?

Paper Review

This is a new subcommittee with C. R. Podas appointed chairman.

General consensus of the committee was that quality of Steam and Power sponsored programs has been good. This new subcommittee provides an important function in carrying out general TAPPI policy and providing extra insurance to be sure our papers are of high quality and completed in time.

This subcommittee's first duties will be associated with the 1960 Engineering Conference papers.

New Development in Equipment for Paper Mill Power Plants (Temporary Subcommittee)

H. R. Emery stated that there are more than 1000 (1128 he said) paper mills with power plants not here represented. Many plant personnel are isolated with little opportunity to stay up to date on power plant developments. Mr. Hoad

moved that a temporary subcommittee be appointed to study and analyze the desirability of forming a permanent subcommittee with objective to prepare annual report on what is new in power plant equipment.

H. R. Emery was appointed temporary chairman to determine what course of activity in this field should be taken.

Publicity

G. B. Gregg was present and reported that he is always willing to do anything possible to publicize activities of the Steam and Power Committee.

Mr. Gregg did an excellent job of contacting the Portland press with coverage of our committee's part at the Portland meeting last year. Unfortunately, the Portland newspapers did not seem to be particularly interested in devoting any space to the TAPPI meeting.

1959 Program

The Steam and Power Committee's session at Pittsburgh will be a continuous three-hour meeting instead of split morning and afternoon sessions as we have had in the past.

The over-all program, the main speakers, and the panel members had been previously finalized and reported in minutes of our Portland meeting. Mr. Hoad reported on his plans for the panel. All who are to participate in the Pittsburgh session clearly understand their part and with the lead time available for preparation of their presentations we will surely have a high quality program of interest to a wide cross section of the TAPPI membership.

TAPPI Headquarters has honored our request to arrange the Engineering Conference program so the Steam and Power Session will not conflict with the Engineering Economics Session. It was felt that many interested in steam and power would also be interested in, and want to attend, programs sponsored by Engineering Economics.

1960 Program

The 15th TAPPI Engineering Conference is scheduled for Oct. 24–28, 1960, at the Robert Meyer Hotel in Jacksonville, Fla. The Steam and Power Committee will have a single three-hour session.

The panel will be on the subject of "Training" with T. F. Woodward the moderator as agreed at our Portland meeting.

Results of balloting for the main papers gave first choice to "Water Treatment for Boilers Operating in the 600 to 1250 Pound Range with High Make-Up." Another ballot is necessary to select "Economics of Feedwater Heating in Paper Mill Power Plants" or "Outdoor Vs. Indoor Paper Mill Power Plants—Trends and Experience in Different Climates" since these two subjects had a tie vote on the "final" previous ballot.

We should be able to finalize this program at the time of our committee luncheon in Pittsburgh.

1961 Meeting

The 16th TAPPI Engineering Conference is scheduled at the Shoreham Hotel in Washington, D. C.

1962 Meeting

The 17th TAPPI Engineering Conference is scheduled at the Queen Elizabeth Hotel in Montreal, Canada.

General Discussion of Conference Operation

One versus Two Steam and Power Sessions

The results of Steam and Power Committee balloting for main conference papers indicates the active interest our members have in many more subjects than can be scheduled in one three-hour session each year. Even so, nine of the 15 committee members present in Chicago voted to continue one three-hour Steam and Power Session at each Engineering Conference instead of requesting space for two three-hour sessions.

Mill Tours

Mill tours and their value was also discussed, the idea being that the Engineering Conference might more profitably schedule four days of sessions instead of three days of sessions plus one day for mill tours. The committee felt that excellent general tours could be planned in some areas. In other areas tours that could be scheduled may be of rather limited interest. In those instances, it might be best to eliminate tours and let individuals having specific interests arrange visits as desired.

The consensus was that TAPPI Headquarters should determine the desirability of scheduling mill tours based on tours available at the Engineering Conference location.

General Discussion of Committee Operation

Mr. Teeple suggested that we adopt additional projects and bring in outside members for subcommittee projects.

F. H. Coldwell mentioned that methods of pulping are changing rapidly and that the power engineer must be familiar with processes and the trends to new or changed processes. Even though not specifically mentioned in the committee, some reporting on processes that affect the steam and power balance might be a suitable project undertaking.

Others commented that:

1. Steam and Power Committee should be out in front leading way to more economical methods of electric power generation. This to provide the rapidly increasing demand for kw. compared to process steam in the paper industry.
2. Need ways of simplifying and reducing costs of paper mill power plants.

There are still opportunities for the Steam and Power Committee to sponsor good papers for publication in *Tappi*. These are in addition to those presented at conferences, and all members should be alert for papers suitable for this purpose.

In general discussions with various committee members, not necessarily in the committee meeting, the following comments seem to repeat themselves:

1. Possible need for interim subcommittee meetings.
2. Should a steering committee be established to outline desired committee activities in more detail for assignment to subcommittees for action?
3. Should the over-all committee be divided into two or more groups, each being assigned only a part of the overall committee scope?
4. How do we get more active participation from each committee member?
5. How do we recruit new members who will participate enthusiastically in our committee activities?

Let's all give operation of our committee some serious thought before our next committee meeting. Even though we may be doing a good job, there are surely many ways to improve the usefulness of our committee.

W. B. Wilson, *Secretary*

Electrical Engineering Committee

The Electrical Engineering Committee met June 17, 1959, at Orono, Me. Members present were:

R. F. Sorenson, *Chairman*
I. Witham, *Vice-Chairman*
G. E. Shaad, *Secretary*
S. Andersen
S. A. Bobe
J. V. Cundelan
S. J. Campbell (for M. H. Fisher)
R. W. Foster
J. F. Fenske
C. G. Herrington
N. D. Kenney
R. J. Minges
L. D. Mower
M. J. Osborne
G. L. Oscarson
M. L. Perkins
D. C. Pier
L. W. Porter
H. W. Thompson

R. J. Farrell
C. L. Harvey
H. A. Wright

Guests present were:

H. O. Teeple
O. L. Calhoun
L. H. Nutter

The meeting was opened at 8:30 a.m. by Chairman Sorenson with a brief coverage of the present subcommittee operations of the committee. He emphasized that each subcommittee was expected to have at least one active project.

Mr. Anderson, reporting for the Publicity Subcommittee, stated that in general, good coverage of committee activities and papers had been obtained in *Tappi*. Some problems still exist in publication delays but he indicated that they were being worked on and that progress was being made. In particular, he desires to obtain monthly publication of committee material rather than occasional large amounts of material.

The "Question and Answer" material was going quite well and Mr. Anderson expressed his personal thanks for the excellent cooperation being received from committee members in this area.

Mr. Teeple commenting for TAPPI Staff reported that additional personnel was being obtained to eliminate some of the past delays. He also suggested that the availability of some "standby" material would help eliminate the dead spots that have occured.

Mr. Osborne advised that the "Question and Answer" material should be controversial in some areas and if so, members should be encouraged to send their comments directly to Mr. Teeple.

Chairman Sorenson, in thanking Mr. Anderson for the report, advised that the chairman of the Publicity Subcommittee, as an over-all committee activity, had been added to the Steering Committee.

Mr. Foster reporting for the Construction Methods and Materials Subcommittee called for a meeting of his subcommittee members in the afternoon. He indicated that work on "Cable Rack Systems," "Special Conduit Systems," and "Fire Alarm Systems" would be considered together with the updating of Data Sheet 157 covering electrical cable.

Chairman Sorenson read a brief report from Mr. Bobe covering the activities of the Drive Requirements—Finishing and Converting Subcommittee. This group's questionnaire on subject interest resulted in the following subjects of primary interest:

1. Rewinder drives, general comparison of various types.
2. Off-machine coater drives, general comparison of various types.
3. Off-machine sheeter and slitter drives, general comparison of various types.

Based upon these results, a project covering rewinder drives is planned for the near future. Mr. Teeple advised that if the subcommittee became involved with corrugator drives, it would be desirable to coordinate with the Engineering Committee of the Corrugated Container Division.

Mr. Herrington reporting for the Drive Requirements—Pulp Mill Subcommittee advised that the next subcommittee project would be on drive requirements for washers, deckers, and other vacuum filters. He requested committee members to advise him of other specific projects they felt should be covered in the near future.

Mr. Cundelan reporting for the Drive Requirements—Paper Mill Subcommittee reported very active interest on the part of the subcommittee members. Planned active projects will include the following:

1. Reactivation of Project No. 622 covering "Drive Requirements—Tissue Machines."
2. Review and Revision of Data Sheets 145A, B, C, and E covering power curves of various sections and speed torque curves of over-all machine characteristics.
3. Addition of "How to Use" information to Data Sheets 145 G and I.

Mr. Cundelan raised a question regarding the delay in publishing revised Data Sheets 145 G and I. These data have had committee approval for a lengthy period of time and were presented in report form at the Portland Engineering Conference.

Mr. Cundelan also requested clarification of the requirements for approval of papers and data sheets.

Mr. Teeple was to review the status of revised data sheets 145 G and I and advise Mr. Cundelan.

Approval routine for authors and published data was discussed and the accepted procedure is given in Appendix A of the minutes.

Mr. Parrish was unable to attend but advised that the Motor and Control Subcommittee was considering the preparation of papers or planned discussions on magnetic amplifier a.c. crane control, continuous digester control systems, sectionalized integrated control rooms, and collector ring spacings on motors and generators.

Mr. Bobe reporting for the Generation and Distribution Systems Subcommittee advised that no subcommittee meeting had yet been held but that one was planned for Pittsburgh. Suggested projects included a data sheet on grounding and lightning protection, a paper on "Air vs. Liquid Cooled Transformers" and a paper on "Equipment Operation with Purchased Power."

It was suggested by the chairman that the proposed monograph on generation and distribution be completed inasmuch as the papers were available and of considerable interest. Mr. Bobe agreed to have this work completed by the Pittsburgh meeting.

Mr. Perkins reporting on personnel advised that he needed added subcommittee membership. His paper on safety had been distributed for comments. He recommended that a project on recruiting be undertaken since this represents a major problem.

Mr. Sorenson thanked the various subcommittees for their active interest and expressed his pleasure at their rapid rate of progress. The transfer of the responsibility for interest and activity to a broader base of active subcommittees should result in a more efficient over-all operation. He emphasized that all subcommittee studies, papers, etc., should carry project numbers. Each subcommittee chairman is responsible for advising the chairman of such work so that project numbers can properly be assigned.

It was requested that all subcommittees make complete minutes of their meetings and that copies of them be promptly forwarded to the Steering Committee for their guidance and information. Subcommittee chairmen who are unable to attend a committee meeting should be certain that they have a representative present to report on their subcommittee activity.

A roster of each subcommittee is listed in Appendix "B" of these Minutes.

In the general discussion of operations and work in process, a monograph on paper machine power requirements was suggested. This possible project was referred to Mr. Cundelan for investigation.

The papers being prepared for presentation at the Pittsburgh Engineering Conference were discussed briefly. All papers are in rough draft form and with one exception have been or are being mailed to the appropriate groups for review and comment. The one exception is the project report on winder power requirements which has been prepared but requires some revision before distribution. It is expected that it will be mailed in the near future.

The data sheets prepared or in preparation were discussed as follows:

Project No. 657—Recommended Maximum Voltage Levels for A.C. Motors. This project is complete. Data sheet as ap-

proved by the committee has been sent to TAPPI headquarters for action.

Project No. 686—Medium Voltage Control. Mr. Wright reported that the material, as prepared, was not particularly adaptable for data sheet presentation. In addition, there was considerable desire to consider rear entry construction as well as front entry construction. It was agreed that this would be dropped as a data sheet project, and that Mr. Wright will expand his present material to include (a) functional specifications, and (b) rear entrance cubicle construction. This material will be presented by title only at the Pittsburgh Conference.

Project No. 739—Effect of Specific Speed Torque Characteristics on Pump Motor Selection. This project is complete. Data sheet as approved by the committee has been sent to TAPPI headquarters for action.

Project No. 740—Winder Power Requirements. Material is in reasonably good form with some details on minimum motor and generator sizes to be worked out. Material will be presented at the Pittsburgh Conference.

Project No. 746—Barking Drum Drives. Proposed data sheet by Mr. Herrington was approved. Mr. Witham will forward to TAPPI headquarters for proper action.

General projects in process were reported upon as follows:

Project No. 368—Power Requirements of Supercalenders. The number of mills indicating an active interest in the testing program was not sufficient to produce valid information. In Mr. Farrell's opinion, concurred in by the committee, the worked involved in making tests on a limited range of supercalenders greatly outweighed the information to be gained. Project will be continued for the present so that Mr. Farrell's committee can incorporate in a brief report, the present status, the types of information required, the questionnaire and test procedure proposed, etc. This material will then be issued as a Special Report and/or published in *Tappi*. This report is to be available for discussion at the Pittsburgh meeting.

Project 620—Power Requirements for Pulp Machines. Mr. Cundelan reported that sufficient power data are now available and that a report should be available for discussion at the Pittsburgh committee meeting.

Project 621—Structural Board Machine Power Requirements. Mr. Campbell reported that data from 14 machines are now available, and a preliminary report should be available for discussion at the Pittsburgh committee meeting.

Project 677—Use of Butyl Cable in the Pulp and Paper Industry. The final report was approved by the committee with the request that it be published in *Tappi* promptly. Mr. Andersen will so advise Mr. Teeple. Data Sheet 157 will be revised by Mr. Foster's subcommittee to include the results of this report.

Proposed papers for presentation at the 1960 Engineering Conference were discussed, with greatest interest being expressed for the following:

1. Ventilation of motor rooms.
2. Selection of motors for refining operations.
3. Selection of motors for washers, deckers, and vacuum filters.
4. Mill experience with sealed motor insulation systems.
5. Motor thrust conditions encountered with flexible couplings.
6. General comparison of rewinder drives.
7. Cable rack systems.
8. Procurement and evaluation of electrical maintenance personnel.
9. Electrical considerations in the use of purchased power.

Because of the active interest in all of these subjects, attempts will be made to find good authors for all subjects. The manner of presentation will be discussed at the Pittsburgh committee meeting.

Meeting was adjourned at 12:00 noon.

G. E. Shaad, *Secretary*

Appendix "A"

Approval of Papers Sponsored by the Committee

1. Rough draft of paper is to be sent by the author to members of the sponsoring subcommittee and the steering committee. (Where time permits, the author may handle the distribution through the subcommittee chairman.) The letter of transmittal will request all comments and suggestions to be returned to the author (with copy to the committee chairman and the subcommittee chairman) by a definite date. Approximately four weeks is to be provided for review and comment. Points of major controversy that might justify rejection of the papers will be discussed with the author by the subcommittee chairman. If the author is in basic disagreement with engineering policy of the committee, the paper will be rejected.

2. Author revises the paper with these comments and suggestions in mind. He is not, however, under obligation to make changes with which he is not in agreement, although it must be understood that if the paper is contrary to committee policy on major points it cannot be sponsored by the committee.

3. Authors final draft is forwarded to the committee secretary for distribution to the committee and subcommittee members for their information.

Approval of Project Reports and Data Sheets

1. Assigned subcommittee personnel draft material.

2. Subcommittee reviews material for engineering content and material arrangement and corrects as necessary.

3. Report or data sheet is forwarded by subcommittee chairman to the committee members advising (a) the material has subcommittee approval and (b) any major objections are returned to the subcommittee chairman with copy to committee chairman by a specified date or approval is assumed to be given. (Four to six weeks time is to be provided.) Normally little or no action should be required by committee members on material that has been properly prepared by the subcommittee. Over-all committee review is, however, a safeguard against errors that might otherwise occur.

4. Subcommittee reviews comments, revises material if necessary, and forwards final draft to TAPPI headquarters for publication. Copies of final draft are to be sent to the steering committee members and the subcommittee members. Where the changes made in the material are minor, a notation to that effect is sufficient.

Note: Where preparation of sufficient copies for distribution to the committee membership is a problem, two copies of the material should be forwarded to Mr. H. O. Teeple at TAPPI Headquarters requesting that TAPPI produce the necessary copies and mail them to the committee membership. Where this is necessary, the subcommittee chairman must advise Mr. Teeple of the required mailing date, the required limiting date on comments, and the exact mailing required.

Appendix "B"

Roster of Subcommittees

Construction Materials and Methods

R. W. Foster, *Chairman*

H. B. Barrow
D. E. Bivins, Jr.
J. V. Cundelan
N. L. Danforth
N. D. Kenney
M. M. Stokely
L. D. Mower
M. J. Osborne
E. G. Parrish
M. L. Perkins
L. J. Randall

Drive Requirements—Pulp Mill

C. G. Herrington, *Chairman*

S. A. Bobe
J. V. Cundelan
M. H. Fisher
R. W. Foster
R. J. Farrell
R. J. Minges
M. J. Osborne
E. G. Parrish
M. L. Perkins
D. C. Pier
L. W. Porter

Drive Requirements—Paper Mill

J. V. Cundelan, *Chairman*

D. E. Anderson
G. E. Clink
C. C. Collins
D. N. Horner
E. J. Klaczkiewicz
R. J. Minges

Chemical Products Committee

N. L. Danforth
R. J. Farrell
M. H. Fisher
R. W. Foster
C. G. Herrington
J. Pearson
M. L. Perkins
D. C. Pier
L. W. Porter
O. R. Witworth

Drive Requirements—Finishing and Converting

P. C. Bobo, *Chairman*

C. C. Collins
R. J. Farrell
R. J. Minges
L. W. Porter

Motors, Generators, and Control Devices

E. G. Parrish, *Chairman*

H. B. Barrow
D. E. Bivins, Jr.
R. J. Farrell
J. F. Fenske
C. L. Harvey
L. D. Mower
G. L. Oscarson
M. L. Perkins
L. W. Porter
H. W. Thompson

Generation and Distribution Systems

S. A. Bobe, *Chairman*

J. V. Cundelan
N. L. Danforth
C. G. Herrington
R. J. Minges
L. D. Mower
L. J. Randall
G. E. Shaad
M. M. Stokely

Personnel

M. L. Perkins, *Chairman*

S. Andersen
R. J. Farrell
M. H. Fisher
C. G. Herrington

Chemical Products Committee

The Chemical Products Committee held its annual meeting at the Hotel Commodore in New York on Feb. 23, 1959. The following attended the meeting:

P. B. Borlew
W. M. Hearon
R. H. McKee
A. S. Gregory
A. G. Durgan
C. E. Tyler
John Dow
D. B. Sparrow
M. L. Taylor
M. B. Pineo
W. P. Newman, Jr.
J. L. McCarthy

Peter Borlew, chairman of the committee, presided.

Change of Scope of Committee Activities

The current Year Book gives the scope as, "The processes of utilizing, refining, and testing the by-products of chemical pulping, such as tall oil, turpentine, and lignin." It was felt that the committee's interest in developing outlets for chemicals from all phases of pulping operations (including waste bark) would be better defined if the scope were changed to read, "The processes of manufacturing, refining, utilizing, and testing the chemical products of pulping, such as turpentine, wood and bark extractives, soap skimmings, tall oil, lignin, dimethylsulphide, carbohydrates, acetic and formic acids, furfural, and other constituents and derivatives of spent pulping liquors." This wording was adopted by the committee members.

Organization of Subcommittees

The former Advisory and Pacific Regional Subcommittees have been abolished. The best way of characterizing the technical subjects covered by the committee, for the purpose of organizing subcommittees, was considered at some length. The proposal that three subcommittees, Lignin, Carbohydrate, and Extractives, be organized, was carried by unanimous vote. The membership of these subcommittees is as follows:

Lignin

S. Coppick
W. M. Hearon
J. L. McCarthy
R. H. McKee
D. B. Sparrow
P. R. Wiley
A. S. Gregory
A. Pollak

Carbohydrate

R. S. Hatch
W. M. Hearon
J. L. McCarthy
E. G. Locke
J. M. Holderby

Extractives

P. B. Borlew
F. H. Gayer
T. H. Hasselstrom
R. Herrlinger
W. P. Newman, Jr.
A. Pollak
J. E. Sapp
M. L. Taylor
C. E. Tyler
W. A. Lawrence
A. S. Gregory

Appointment of Chairmen

The following appointments were made:

Lignin Subcommittee—P. R. Wiley, *chairman;* Sydney Coppick, *co-chairman*
Carbohydrate Subcommittee—E. G. Locke, *chairman.*
Extractives Subcommittee—C. E. Tyler, *chairman;* J. E. Sapp, *co-chairman*

The chairman of each subcommittee should appoint his own secretary.

Function and Working Programs of Subcommittees

The chairman of each subcommittee will be asked to secure from two to three papers for the TAPPI Annual Meeting in 1960. Round-table discussions or symposia can be substituted for papers.

The subcommittee should also discuss their own programs which may comprise industry-wide questionnaires and surveys, TAPPI monographs in their respective fields, applications for TAPPI Research Grants for worthy projects, etc., etc. They are also asked to maintain or cultivate contacts with other committees of TAPPI or non-TAPPI organizations when common interests exist.

D. B. Sparrow, *Secretary*

Statistics Committee

The TAPPI Statistics Committee met Feb. 23, 1959, at the Hotel Commodore, New York, N. Y. Present at the meeting (noncommittee members marked with asterisk):

Blew, M. E., Strathmore Paper Co., West Springfield, Mass.
Carlson, W. E., St. Regis Paper Co., Carthage, N. Y.
Fuller, R. R., Gulf States Paper Corp., Tuscaloose, Ala.
Geiger, T. H., Oxford Paper Co., Rumford, Me.
Gilmore, D. M., Brown Co., Berlin, N. H.
Hartwell, F. C., Peter J. Schwitzer Div., Kimberly-Clark Corp., Lee, Mass.
Hoffman, E. R., Oxford Paper Co., Rumford, Me.
Hooper, R. L., Ecusta Paper Corp., Pisgah Forest, N. C.
Koon, C. M., Eastern Corp., Fine Paper and Pulp Division, Bangor, Me.
LaDue, Hal, American Paper Bottle, Walled Lake, Mich.

Langmaid, J. F., Jr., S. D. Warren Co., Cumberland Mills, Me.
Lashof, T. W., National Bureau of Standards, Washington, D. C.
*Mandel, John, National Bureau of Standards, Washington, D. C.
Patek, J. M., Eastman Kodak Co., Rochester, N. Y.
Renner, M. S., Dewey & Almy Chemical Co., Cambridge, Mass.
Roberts, R. W., Marathon, Div. of American Can, Rothschild, Wis.
Sheldon, F. R., Inorganic Research and Development Dept., Food Machinery and Chemical Corp., Princeton, N. J.
Smaine, H. L., P. H. Glatfelter Co., Spring Gove, Pa.
*Stobo, W. E., Anglo Paper Products, Ltd., Quebec, P. Q.
Strieby, J. G., Kimberly-Clark Corp., Neenah, Wis.
Theriault, J. F., Robert Gair Div., Continental Can Co., Uncasville, Conn.
*Troster, M. J., Union Bag-Camp Paper Corp., Savannah, Ga.
Vroom, K. E., Pulp and Paper Research Institute of Canada, Montreal, P.Q.
Yateman, D. A., Dixie Cup Div. of American Can Co., Easton, Pa.

Selection of Officers

M. S. Renner has been appointed chairman and W. E. Carlson, secretary of the TAPPI Statistics Committee for the year 1959 by the chairman of the Research Development Division of TAPPI.

Reports of Subcommittees

TAPPI-CPPA Statistics Course

K. E. Vroom reported that the 1959 TAPPI-CPPA Statistics Course will be offered at Dartmouth College, Hanover, N. H., July 20–31. Jack Winchester of TAPPI will handle publicity. The basic course will be under the direction of Geoffrey Beall, and Fred Sheldon.

Instructors for the advanced seminar will be announced later. For the first time, one flat rate of $280 will apply to both sections of the course which includes board and room for the two weeks at the Hanover Inn.

Chairman Renner suggested that North Carolina State be considered for the 1960 course and Mr. Fuller suggested, Georgia Tech in Atlanta. It was moved by Fred Sheldon, seconded by R. R. Fuller that if possible it should be arranged to hold the 1960 TAPPI-CPPA Statistics Course at North Carolina State, Raleigh, N. C. The motion carried.

Sampling Plans Subcommittee

Mr. Hoffman, chairman, reported a $2000 TAPPI Grant No. 163 had been approved for the first phase of the project "Sampling Plans for the Acceptance or Rejection of Skid Lots of Cut Paper." It is expected this phase will require one year and the subcommittee will do the final reporting.

Statistics Committee

Publications Subcommittee

Chairman Renner reported that the Publications Subcommittee has been inactive since the publications of TAPPI Special Report, No. 420, "Statistical Methods and Controls in the Pulp and Paper Industry," and that T. H. Geiger had resigned the chairmanship. Mr. Renner expressed the appreciation of the committee to Mr. Geiger for his work as chairman.

F. C. Hartwell moved, seconded by M. E. Blew, that R. R Fuller be appointed chairman of the Publications Subcommittee (carried). Mr. Fuller lead a discussion of the subcommittee program. It was the concensus of those present that the Publications Subcommittee should accept publications from all TAPPI Statistics Subcommittees and members and prepare them for publication, as well as other worth-while papers from outside the committee. W. E. Stobo, Anglo Paper Products, Ltd., stated that H. M. Banfill, Howard Smith Paper Mills, Cornwall, Ont., was editing a CPPA publication, "Introduction to Statistical Methods as Solution to Industry Problems." Mr. Hoffman suggested the Publications Subcommittee should consider this publication and a list of abbreviations of statistical terms as possible publication projects.

Organization Subcommittee

Chairman Renner reported that TAPPI has restricted all reorganization of committees until the parent organization has been completed its reorganization.

Chairman Renner posed the question is the name "Statistics Committee" adequate to define and describe the functions of the committee? The need for more emphasis on quality control and liaison with other committee chairmen was discussed.

Design of Experiments Subcommittee

J. G. Strieby, chairman, reported members of the Statistics Committee had been polled as to the possible activities of the subcommittee. Ten who agreed to serve as members of the subcommittee were also in substantial agreement that the committees objectives should be education and promotion. Implementation of the subcommittee program should include TAPPI publication of existing experimental designs, papers at the National TAPPI Convention, speakers for local TAPPI meetings, summer courses, and research and appraisals of new designs. The book, "Planning of Experiments," by D. R. Cox, John Wiley & Sons, was recommended.

New Business

T. W. Lashof moved, seconded by F. C. Hartwell, that the Statistics Committee establish a Quality Control Subcommittee (carried). A subcommittee composed of Messrs. J. F. Theriault, chairman, R. R. Fuller, F. C. Hartwell, J. F. Langmaid, Jr., and D. A. Yateman was initiated by Chairman Renner with the initial objectives of presenting the advantages, limitations, and costs in setting up a quality control department.

The Operations Research Subcommittee was tabled until next year.

T. W. Lashof and Don Gilmore agreed to serve on the subcommittee on computer application and programing pending someone accepting the chairmanship.

John Langmaid, Jr., seconded by Fred Sheldon, that the chairman be empowered to appoint a nominating committee to present a slate of officers for the following year which will be submitted to the members of the Statistics Committee by mail ballot. The terms of office will be for two years (carried). Since the chairman and secretary are by appointment of the chairman of the TAPPI Research and Development Division, the names selected by ballot will be recommended for appointment. The installation of officers on even number

Deinking Committee

years will be the first order of business at the annual Statistics Committee meeting.

Meeting adjourned 11:55 a.m.

W. E. Carlson, *Secretary*

Deinking Committee

The TAPPI Deinking Committee met at the Hotel Commodore, New York, N. Y. on Monday afternoon, Feb. 23, 1959. Twenty members were present. Chairman J. J. Forsythe, International Paper Co., Niagara Falls, N. Y., presided.

John Wendell, Tileston and Hollingsworth Co., Hyde Park, Mass., Chairman of the 4th Deinking Conference, reported on plans for the conference to hold the Conference in The Roger Smith Hotel, Holyoke, Mass. The morning sessions will be devoted to the technical program; the afternoon sessions to plant visits.

Mr. Wendell reported that T. T. Allan, Virginia Smelting Co., Walpole, Mass., had agreed to handle the budget and financial matters for the Conference.

H. E. Corwin, chairman of the Program Committee, outlined his proposals for the technical program. He proposed sessions on:

1. Flotation Deinking
2. Deinking Waste Disposal
3. Chemical Recovery

M. D. Reuben suggested that each program should contain something on deinking fundamentals, either by way of review or updating.

A progress report on the Deinking Project No. 732 was given. Forty-six questionnaires had been sent out. So far one had declined and 19 replies had been received. A full report will be made and discussed later. It was suggested that this be done as part of the conference program.

It was reported that the committee's research proposal concerning the chemistry and identification of materials producing sticky spots in deinked stock had again been denied funds by the Research Appropriations Committee. Three or more negative votes are sufficient to deny the request. The reasons for denial were summarized as:

1. Not a proper subject for a research project.
2. Only a small number of mills of the industry would benefit.
3. The project is one which should properly be worked out between the mills and their suppliers.
4. The project should possibly be considered for joint sponsorship with the Waste Paper Utilization Council.

After discussing the matter the following proposals were made:

1. That we keep trying.
2. That we resubmit the proposal.
3. That the base of investigation be broadened.
4. That the investigation be broken-down into small steps involving lesser amounts of funds.
5. That a copy of the proposal be submitted to Mr. F. Doane as he suggested so that he could discuss it with the Executive Committee.

In discussing standard methods of deinking, R. W. Kumler suggested that perhaps what was needed was not a standard method for deinking but a standard method for sampling. He reported that he had recently heard of a new bale sampler and would give more details later.

Mr Kumler suggested that a letter be sent to the Technical Committee of the Adhesive Manufacturers Group proposing a joint meeting to discuss adhesives and their effect in waste paper. It was decided to leave this to the incoming chairman.

The following officers for the coming year:

Chairman, H. D. Boggess
Vice-Chairman, E. F. Andrews
Secretary, A. J. Felton

It was proposed that consideration be given to having the change of officers occur following the Deinking Conference rather than in February.

It was also proposed that consideration be given to holding the Deinking Conference every 2 years instead of every year.

The meeting was closed in due order. The next scheduled meeting of the committee will be in the evening of October 7 in Holyoke, Mass.

E. F. Andrews, *Secretary*

Adhesives Testing Committee

The eighth meeting of the Testing of Adhesives Committee was held on May 13, 1959, at TAPPI Headquarters, New York, N. Y.

Members present: Neuss, Carey, Adams, Bearman, Fisher, Fox, Godshalk, Hirsch, Myers, Psyras, Schmid, Shirley, and Weizenhoffer.

Guests: J. J. Bikerman of M.I.T., L. R. Brantley of Lehigh, R. E. Lafler of U. S. Envelope, and H. S. Eldridge of United Paste and Glue Corp.

The meeting opened at 10:15. The minutes of the February 24 meeting, as published by the secretary, were accepted.

The committee has been requested to conduct a full-day meeting during the Eleventh Testing Conference at Grand Rapids, Mich., in September, 1960. It was suggested that a general session incorporating a question period on problems of testing might be interesting. From the committee, a panel

Adhesives Testing Committee

could be selected which could deal with any facet of adhesives testing. Members were asked to give some thought to this approach and to the make-up of the suggested panel. Also requested were ideas for other subject matter for such a meeting. The entire question will be discussed in greater detail at the September meeting.

The chairman raised the question of the best approach to developing test methods to predict "machineability" or on-machine behavior of adhesives. The question could be dealt with in detail by the group working on each type of adhesive. It might also be made the subject of a separate chapter in the monograph. It was voted that each committee member submit in person, or in writing, before the September meeting his views on the factors involved in machineability. It should be borne in mind that there is no complete agreement as to what the factors are and that a good definition of the problem must be prepared before a plan of attack can be formulated.

The chairman led a discussion on the possibility of setting up a joint research project at a university. Possible sponsors mentioned were: TAPPI, the Adhesive Manufacturers' Association, Packaging Institute, and a packaging machinery manufacturing group. Defining the problem and monitoring the progress of such work would not be insoluble. Messrs. Bikerman and Brantley laid stress on the importance of clearly defining the problem for such a project. Both felt, based on their university research experience, that a well-defined problem was more easily approached. The difficulty of stating the problem should not be underestimated. Mr. Bikerman summarized his thoughts in defining mechineability as the capacity of an adhesive to be used in high-speed machinery. He felt it would be difficult to tie together the loose ends and to set up a simple problem scientifically to attract collegiate interest. The chairman agreed that it was difficult but felt that the committee was equal to the task.

Mr. Brantley pointed out that Lehigh has had considerable experience working with the leather and printing industries and possibly someone there might have suggestions.

Mr. Bikerman commented that ideally, the problem should be stated scientifically, in terms of fundamental properties of viscosity etc. Mr. Brantley pointed out possible problems relating to the measurement of viscosity where the nature of the material under test causes some change in the test instrument, such as filming of capillary walls.

It was agreed that the committee would proceed to define the problem and then take steps to obtain assistance toward its solution.

Mr. Bikerman spoke informally on the tackiness of liquid adhesives, defining tack as the ability to form a bond at relatively low pressure and high speed, and then display some resistance to separation while the adhesive is still liquid. Much of the work he has done has verified Stefan's work in the previous century.

Mr. Brantley's remarks were directed to reviewing fundamentals. Primarily we are forming a coating in place, wetting two surfaces, hardening the film, and then testing the film for failure in the adhesive or cohesive layer. We are dealing with surfaces and we must remind ourselves that the surface mechanisms are quite important.

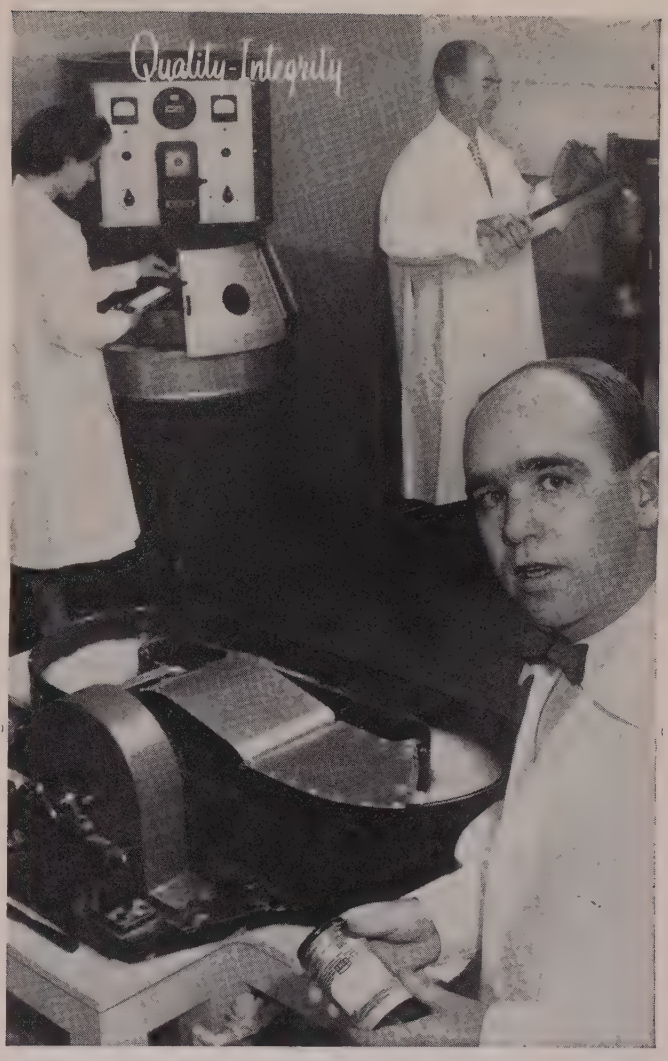
The chairman reported that the Gummed Industries Association is making considerable progress in preparing test methods.

Psyras reported the existence of a slow-motion film on the action of adhesives at varying packaging machine speeds. He will investigate the possibility of obtaining a print for a showing for the committee.

The next meeting will be held on Sept. 16, 1959, in New York. The vice-chairman will undertake to locate a suitable meeting place, the present meeting room being too small.

The meeting adjourned at 4:30 p.m.

J. P. Carey, Jr., *Secretary*



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ENGINEERING DIVISION

Committee Contributions

Questions and Answers

(*13*) *Question:* I understand that there is some controversy in the paper industry regarding the reliability of large electric motors, particularly large low speed synchronous motors. One machinery insurance company published an article which contained the following paragraph:

"It is interesting to note that the failure rates for certain types of units increase as the size of the unit increases. The experience on electric motors, as shown in the following table, is a good illustration of this trend:

Motor capacity, hp.	*Annual average failure rate*
5 or less	0.0143
6–25	0.0192
26–100	0.0268
101–1000	0.0341
Over 1000	0.0409

"It will be observed that the failure rate of large motors over 1000 hp. in capacity is approximately three times the failure rate for small motors of 5 hp. or less. It would be expected that the reverse of this trend would be more likely because usually more attention is given to the protection and care of large units. On the other hand, large motors may be subjected to higher load and demand factors."

This article has stimulated considerable interest among certain paper mills, machinery, and motor manufacturers. It would be of considerable interest to know the types of failures upon which these statistics have been based. It would be of further interest to learn which factors an insurance company considers of greatest importance when they are determining the rates for insuring rotating electrical apparatus.

(*13.1*) *Answer:* Your question is very interesting and we can believe that the statistics quoted in this article are taken from the case histories of the insurance company. It is my feeling, however, that the failure rate as set forth does not present an analysis of all motor failures in all industries, but only those within the knowledge of the insurance company and its records. For example, it is common practice to insure large motors over 200 hp. It is not usual practice to insure motors under 200 hp. This practice of purchasing insurance would naturally lead to some interesting statistics from the insurance companies on rates of failure.

In the paper industry, it has been customary to drive large vacuum pumps with low speed synchronous motors. In most cases these motors have been open motors, or at best dripproof. These machines have been very reliable and have performed more satisfactory than other driving motors in the paper mill.

Motors up to 125 hp. are quite frequently "mush" or random wound machines. There is no wrapper of insulation around the coils. For the most part, the insulation relied upon is the varnish supplied on the copper wire.

The coils in the larger motors are usually form-wound with a generous wrapping around each coil for ground insulation. The coils are all tested individually before they go into the machine. The coils are tested individually after they are placed in the machine; then the winding tested after it is made up. This care is almost never taken with the small random wound motors.

Recently the trend has been to group vacuum pumps with a single driving motor in the center of the group with resulting economy to the paper mill customer. Quite often the protection provided to this single driving motor approaches that of the main power generator in the power plant. Embedded temperature detectors, total enclosure of the winding, temperature alarms, differential winding protection and other features have been frequently utilized. The turbogenerator has long been recognized as the most reliable piece of rotating apparatus in industry.

(*16*) *Question:* What is meant by Taylor vortices and what is their physical significance in the papermaking process?

(*16.1*) *Answer:* The so-called Taylor vortices are doughnut shaped vortex tubes which are formed in the annular space between two concentric cylinders when these are rotated above a certain critical relative speed. The vortices are periodic along the cylinder axis, the adjacent ones rotating in oppoite directions, and the spacing of each pair is twice the thickness of the annular space. These principles were developed by Sir G. I. Taylor of England and their applicability to papermaking is fully investigated in a paper by C. A. Lee, *CPPA Proceedings*, 1956. Lee showed how this principle was actually used to produce controlled turbulence from a paper machine headbox. The principle has far greater applicability, however, and is responsible for the well-known tendency to form ridges following any curvature in flow such as in the paper machine slice, around a table roll, or in a roll type coater.

(*17*) *Question:* What is meant by Froude number?

(*17.1*) *Answer:* Froude number is the ratio of the velocity of flow to the velocity of small gravity waves on the free surface of a liquid. It is also equal to the square root of the ratio of the velocity head to the depth of the liquid. When the Foude number is equal to one it is called critical because above this value it is impossible for the waves to travel upstream. Therefore, it is analogous to the Mach number in aerodynamics. The flow on the fourdrinier wire on most paper machines is highly critical in this sense, which accounts for the typical diagonal pattern of the waves of supersonic airplanes. The Froude number is useful in characterizing the condition of flow associated with the severe surface disturbances which are observed on high speed paper machines and which are known to have a profound effect on the quality of the paper that is produced.

(*19*) *Question:* We recently installed two identical vertical hollow shaft pumps with 125 hp.-drive motors. These pumps were connected in parallel and were equipped with discharge valves. It was noticed that if one pump were running and the discharge valve closed, the motor would trip due to overload. It was also observed that if both pumps were running, the pressure was too high and both motors were overloaded. The load changes were in the order of 40%. Are these conditions not contrary to the general experiences with centrifugal pumps and their loads?

(*19.1*) *Answer:* In all probability these two pumps are either mixed flow or axial flow. In the case of conventional radial flow pumps the torque requirement is less at zero flow (closed discharge) than at rated flow; the converse is true in the case of mixed flow or axial flow pumps. These characteristics are necessarily reflected in drive motor input at restricted pump outputs and in the pull-in torque requirements for synchronous motors. Obviously mixed flow or axial flow pumps should be started open discharge if possible; and continued operation at closed discharge will overload the driving motor. NEMA has proposed torque values per MG1-8.10 for various types of pumps and started with full casing. The Electrical Engineering Committee of TAPPI has sponsored a proposed data sheet, "Effect of Specific Speed—Torque Characteristics on Pump Motor Selection and Operation." This data sheet should be published in the near future. In the meantime, I suggest that you refer to an article by G. L. Oscarson in the "E-M Synchronizer" Pump No. 200-SYN-33. In this article, Mr. Oscarson discusses horsepower and head characteristics for various types of centrifugal pumps.

(*20*) *Question:* What is the most important single tool available to the stress analyst?

(*20.1*) *Answer:* The bonded wire resistant strain gage which has the property of linear variation of electrical resistance with strain is the most important tool available to the stress analyst.

(*21*) *Question:* What is used to measure change in strain gage resistance in terms of unit strain?

(*21.1*) *Answer:* For precision measurements of strain gages, a principle named the "Wheatstone bridge" is employed. Special bridges are designed for use with strain gages so that the balancing control is calibrated to give a reading of microinches per inch so that the unit strain can be read directly from the charts.

14th Engineering Conference

Hotel Penn-Sheraton, Pittsburgh, Pa.

Oct. 11–15, 1959

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Review of 1958–59 Section Meetings

The following review is a record of the meetings held by the local sections of the Technical Association of the Pulp and Paper Industry, between July, 1958, and June, 1959. A report of the meetings held in 1957–58 was published in the August, 1958, issue of *Tappi*.

Pacific

The Pacific Section was organized in Seattle, Wash., in June, 1929.

Sept. 15 and 16, 1958 (Camas, Wash.).

Sept. 18 and 19, 1958 (Seattle, Wash.): The Twelfth Annual Seminar. "Some Recent Researches on Cellulose and Some Fundamental Principles of Physical Chemistry," by Henry Eyring, Professor of Chemistry and Dean of the Graduate School, University of Utah, Salt Lake City, Utah; "Development of Physical Principles Needed to Treat Absolute Reaction Rate Theory, Viscosity, Diffusion"; "Viscosity and Diffusion and What They Reveal about Cellulose"; "Swelling and Osmotic Pressure Measurement of Cellulose and Cellulose Products"; "Some Important Cellulose Reactions."

Sept. 17, 1958 (Everett, Wash.): Instrumentation Meeting. Technical Meeting, Elks Lodge, Everett, Wash. Moderator: Arthur Dammann, Alaska Lumber & Pulp Co., Inc., Seattle, Wash. "Continuous Moisture Control of Pulp and Paper by Capacitance Method," by Ray Austin, The Foxboro Co., Foxboro, Mass.; "Moisture Control on a Newsprint Machine," by Cliff Mayer, Publishers' Paper Co.. Oregon City, Ore.; "Measurement and Control of Moisture in Paper by the Electrical Conductivity Method," by Vernon S. Robyn, Minneapolis-Honeywell Regulator Co., Seattle, Wash.; "Continuous Moisture Measurement at Crown Zellerbach, West Linn," by Edwin A. Woodworth, Jr.; "Some Applications of Nuclear Magnetic Resonance to Measurements on Paper and Associated Products," by J. M. Cotton, Ridgefield Instrumentation Div., Schlumberger Well Surveying Corp. Dinner, "Elks Lodge." Dinner speaker: Henry Eyring, University of Utah, Salt Lake City, Utah.

Nov. 18, 1958 (Longview, Wash.): Papermaking. Moderator: Jack Weiblen, Columbia River Paper Mills, Vancouver, Wash. "White Water Clarification," by Jack Decker, Columbia River Paper Mills; "Application of Enzyme Converted Starches," by Delos D. Wilma, Longview Fibre Co., Longview, Wash.; "Surface Treatment of Paper and Paperboard with Starch and Pigment," by John T. Bainbridge, Penick and Ford, Ltd. Dinner, Monticello Hotel. Dinner speaker: Bruce Johnson, Rayonier, Inc., Seattle, Wash., "Washington State Finances."

Jan. 20, 1959 (Aberdeen, Wash.): Technical Control Methods. Technical meeting, Lodge Room, Aberdeen Elks Club, Aberdeen, Wash. Moderator: Curt Walseth, Weyerhaeuser Pulp Division, Cosmopolis, Wash. "The Waring Blendor as a Laboratory Beater," by B. J. Jacoby, Crown Zellerbach, Camas, Wash.; "The Performance of an Automatic Titrator in Routine Pulp Testing," by A. J. Beauchamp, Crown Zellerbach, Camas, Wash.; "Weighing Chips by Scow Displacement," by Vance Reynolds, Puget Sound Pulp and Timber Co., Bellingham, Wash.; "Application of Wet Ashing to the Analysis of Pulp Mill Samples," by Luella Johnson, Puget Sound Pulp and Timber, Bellingham, Wash.; "Control Sampling of Pulp Mill Effluent," by Fred A. Westfall, Scott Paper Co., Everett, Wash.; "Quick Brightness Test on Slush Stock," by John M. Elder, Weyerhaeuser Kraft Mill, Everett, Wash.; "Improved Procedure for Estimation of Certain Sulphur Compounds in Kraft Pulp Mill Effluent Streams," by J. L. McCarthy and V. F. Fellicetta, Chemical Engineering Dept., University of Washington; "Testing the Printability of Pulps, by J. H. Baxter, Crown Zellerbach, West Linn, Ore. Dinner, Morck Hotel. Dinner speaker: Charles E. Young, Economist, Weyerhaeuser Timber Co., Tacoma, Wash., "Economic Outlook for Pulp and Paper."

April 7, 1959 (Camas, Wash.): Shibley Award Meeting. Honoring the Past Chairmen, Pacific Section TAPPI; and celebrating Pacific Section TAPPI 30th Anniversary. Technical Meeting, Crown Zellerbach Corp., Central Research Department Auditorium, Camas, Wash. "The Frag Tester—A Design Tool for the Sack Maker," by Sangho Back, Central Research Department, Crown Zellerbach Corp., Camas, Wash.; "Some Aspects of Towel Manufacture," by J. P. Bell, Westminster Paper Co., New Westminster, B. C., Canada; "Scrubbing Kraft Recovery Furnace Gases," by J. S. Murray, Weyerhaeuser Timber Co., Kraft Mill, Everett, Wash.; "Case Sealing at the Camas Converting Plant," by Richard L. Carlson, Crown Zellerbach Corp., Camas, Wash. Norman S. Lea, Scott Paper Co., Everett, Wash., who is immediate past chairman of Pacific Section, moderated the program.

This being Pacific Section's 30th Anniversary, a special program honoring the past chairmen was planned. Those past chairmen present were: Carl Fahlstrom, G. H. McGregor, N. W. Coster, C. A. Enghouse, H. W. Bialkowsky, Fred Weleber, John McEwen, Ben T. Briggs, and N. S. Lea. Special tribute was paid these men who contributed so much to the growth and strength of our section. Chairman Paul Billington presented each of them with an engraved gift as a token of appreciation of our membership. Dinner, East Room, Crown Zellerbach Hotel. Dinner speaker: Philip E. Nethercut, Secretary-Treasurer TAPPI, New York, N. Y.

May 21, 22 and 23, 1959 (Gearhart, Ore.): Joint Meeting Pacific Coast Division The American Pulp and Paper Mill Superintendents Association and Pacific Section, Technical Association of The Pulp and Paper Industry, Gearhart Hotel, Gearhart, Ore. The Theme of TAPPI'S part of the program was "Multiple Water Use." Chairman: Norval Magnusson. "Water Quality Criteria as They Relate to Beneficial Water Uses," by Vinton W. Bacon, Executive Secretary, Northwest Pulp and Paper Association, Tacoma, Wash.; "Legal Aspects of Multiple Water Use," by Daniel C. Smith, Weyerhaeuser Timber Co., Tacoma, Wash.; "The Conservationist's Viewpoint," by L. C. Binford, Vice-Chairman, National Executive Board, Izaak Walton League of America, Portland, Ore. Industries' Use of Bio-Assay Methods—"Bio-Assay Techniques Used in Tests at Simpson Paper Co.," by Dwayne J. Clark, Simpson Paper Co., Everett, Wash.; "Bio-Assays—A Tool of Industry," by Norman S. Lea, Scott Paper Co., Everett, Wash.; West Tacoma newsprint paper by James Cooper; "Relationship of Fisheries Statistics to Industrial Wastes," by Roger Tollefson, Consulting Biologist (Paper read by Dick Petersen, Rayonier Marine Laboratory); "Accomplishments of Mills on Water Quality Control," by S. K. Pratt, St. Regis Paper Co., Tacoma, Wash.

Golden Gate District (Pacific Section)

The Golden Gate District of Pacific Section TAPPI was organized in San Francisco, Calif., in October, 1957.

Lake States

The Lake States Section was organized at Menasha, Wis., on Oct. 17, 1930. Meetings are held usually on the second Thursday of the month.

Oct. 14, 1958 (The Institute of Paper Chemistry, Appleton, Wis.: Symposium on "Recent Researches on Cellulose and Some Fundamental Principles of Physical Characteristics" by Dean Henry Eyring, Graduate School, University of Utah, guest lecturer and discussion leader.

Nov. 11, 1958 (Elks Club, Wausau, Wis.): "Controlled pH Sulphite Pulping." Papers presented: "The Arbiso Process," by J. W. McKinney, Abitibi Power and Paper Co., Sault St. Marie, Ont.; "Mill Scale Trial Run with the Magnefite Process," by L. T. Welch, T. G. Sheridan, G. H. Tomlinson II, Howard Smith Paper Mills Ltd., Cornwall, Ont.; "The Bisulphite Soda Process," by J. S. Buchanan and E. H. Kennedy, Nekoosa Edwards Paper Co. and Combustion Engineering Inc. Visits made to Rothschild Mill of Marathon Division American Can Co. and Wausau Paper Mills, Brokaw, Wis. Panel discussion following dinner with afternoon speakers, D. J. McLaurin, the Institute of Paper Chemistry, moderator.

Jan. 13, 1959 (Conway Hotel, Appleton, Wis.): "Coating." Panel discussion—John Swanson, the Institute of Paper Chemistry, moderator. Panel members, R. A. Vogt, Combined Locks Paper Co.; Frank Kaulakis, Consolidated Water Power and Paper Co.; A. Lewenstein, Appleton Coated Paper Co.; Philip A. Peterson, Rice Barton Corp., Worcester, Mass. Mill visit to Appleton Coated Paper Co.

April 15, 1959 (Elks Club, Appleton, Wis.): "Engineering Meeting." Plant visits to Appleton Machine Co., Appleton Woolen Mills and Valley Iron Works. Evening speakers—Tany Agronin, Appleton Machine Co., "Some Projects at Appleton Machine"; L. R. Barlament, Appleton Woolen Mills "Problems of Paper Machine Felt Manufacture"; George Reynolds, Valley Iron Works "Quick Wire Change Equipment for the Cantilevered Fourdrinier."

May 12, 1959 (Elks Club, Menasha, Wis.) "C. J. West Award Meeting." Winning papers presented by R. A. Walch, Green Bay Paper & Pulp Co., "Differential Speed Measurement on the Paper Machine"; W. A. Dickens, Kimberly-Clark Corp., Neenah, Wis., "Post Pressure Roll Yankee Drier Sheet Consistancy Determination by Material and Enthalpy Balances"; Frank P. Hughes, Marathon Division American Can Corp., Rothschild, Wis., "Precision Method for Analysis of Mixtures of Long and Short Fiber Pulps.'

Delaware Valley

The Delaware Valley Section was organized at Philadelphia, Pa., on Nov. 12, 1931. Meetings are generally held on the fourth Thursday of the month at the Engineers Club in Philadelphia.

Sept. 26, 1958 (Pusey & Jones Corp., Wilmington, Del., and the Kent Manor Inn, Wilmington, Del.): Afternoon tour of Pusey & Jones Corp. Paper Mill Maintenance Panel following dinner meeting with George Cannie, Maintenance Supervisor, Continental Paper Co., as moderator. Serving on the panel: John Knox, Maintenance Supervisor, Schmidt & Ault Paper Co., "Work Scheduling in Maintenance"; Arther J. Weiss, Plant Mgr., Lowe Paper Co., "Incentive Systems in Maintenance."

Oct. 23, 1958 (Engineers Club, Phila., Pa.): "Present Improvements and the Future Outlook of the Cylinder Machine" (Stevens Former), by Derry Akeroyd, Sales Engineer, Beloit Iron Works.

Nov. 21, 1958 (Engineers Club, Phila., Pa.): "Conical Versus Disk Refiners—Theory and Mechanics," by A. J. Felton, Executive Sales Engineer, The Black-Clawson Co.

Jan. 22, 1959 (Engineers Club, Phila., Pa.): Philadelphia Graphic Arts Conference (afternoon and evening). The conference was sponsored by the Delaware Valley Section with the cooperation of the Philadelphia Printing Ink Makers Production Club, and the Philadelphia Club of Printing House Craftsmen. Frederic Dannerth, Technical Advisor to the Graphic Arts Industry was special chairman. Opening address by George D. Beck, President of the Printing Industries of Philadelphia. Speaking for the Printers; Walter Arader, Edward Stern & Co., Inc., and George Hess, Franklin Printing Co.; speaking for the Ink Makers: Joseph F. Krause, Rexford Printing Inks, and Morris Garrick, McCutcheon Bros. & Quality Printing Inks; speaking for the Papermakers: Loyal Radke, Hopper Paper Co., and Howard Ferguson, Curtis Paper Co. Harry Seeburger, of Arndt, Preston, Chapin and Lamb was moderator of the conference.

March 26, 1959 (Engineers Club, Philadelphia, Pa.): "Paper Mill Management" by L. A. Moss, Paper Mill Manager, Riegel Paper Corp., Milford, N. J.

April 23, 1959 (Engineers Club, Philadelphia, Pa.): "How the Chemicals in Modern Papers Affect the Application of Modern Printing Inks," by Edward Wade, General Printing Ink Co. Div. of Sun Chemical Corp.

May 22, 1959 (Hercules Powder Co. Country Club, Wilmington, Del.): Afternoon golf outing and evening dinner meeting. "F.D.A. Laws and Requirements Relative to Paper and Board for Food Packaging," by Robert C. Stanfill, Chief of the Philadelphia District, Food and Drug Administration.

Kalamazoo Valley

The Kalamazoo Valley Section was organized on May 4, 1931, at Kalamazoo, Mich. Its meetings are held usually on the first Thursday of each month at the Hotel Harris in Kalamazoo.

Oct. 2, 1958 (Hotel Harris, Kalamazoo, Mich.) Panel discussion, "Cost Control for the Paper Industry," by Robert Wetnight, Western Michigan University; Robert Miller, The KVP Co.; and Bernard White, Sutherland Paper Co., "Costs and Cost Controls," by W. P. Gullander, Weyerhauser Timber Co.

Nov. 6, 1958 (Hotel Harris, Kalamazoo, Mich.): "Process Design for Instrumentation," by James E. Overall, Fischer and Porter Co., Hatboro, Pa.

Dec. 4, 1958 (Inman's, Galesburg, Mich.): "Workshop on Communication Problems," by Vernon Wanty, Battle Creek Community College; movie "Production 5118," Champion Paper and Fibre Co. and "How to Make a Conference Succeed," by Jesse Rogers, Champion Paper and Fibre Co., Hamilton, Ohio.

Jan. 15, 1959 (Hotel Harris, Kalamazoo, Mich.): "Papermakers' Night." "The Technical Man and the Practical Man," by A. E. Bachmann, Missiquoi Corp., Sheldon Springs, Vt.

March 19, 1959 (Inman's, Galesburg, Mich.): "Absorptivity," by G. R. Sears, the Institute of Paper Chemistry, Appleton, Wis. "Surface Configuration," by R. L. James, Western Michigan University, Kalamazoo, Mich.; "Compressibility," by A. T. Luey, Boxboard Rearch and Development Association, Kalamazoo, Mich.; "Ink Film Splitting Movie," by J. F. Steinbruner, Interchemical Corp., Chicago, Ill., and "Direct Tests for Evaluation of Printability of Paper and Paper Board," by W. R. Roehr, Kimberly-Clark Corp., Neenah, Wis., and C. G. Eckhart, Ohio Boxboard Co., Rittman, Ohio.

April 23, 1959 (Inman's, Galesburg, Mich.): "Papermaking Felts," by Otto Berggren, Huyck Felt Co., Rensselaer, N. Y.

May 14, 1959 (Hotel Harris, Kalamazoo, Mich.): "Recognition Night." The TAPPI Award Winners, Department of Paper Technology, Western Michigan University: Earl Malcomb, "Determination of the Chemical Composition to Hydrolyzed Monosaccharides by Paper Chromatography; Thomas Elias, "Fibrous Papermaking Materials Improved or Developed since 1950," and Uldis Ievans, "Study of Reuse of Clarified Deinking Cooking Liquor."

June 23, 1959 (Gull Lake Country Club, Richland, Mich.) "Annual Fun Day."

New England

The New England Section was formed at Holyoke, Mass. on Dec. 9, 1932.

Oct. 3-4, 1958 (Berkshire Inn, Great Barrington, Mass.) Theme—"Cost Reduction via Quality Control." Panel Discussion: "Discussion of Methods to Effect Cost Reduction by Use of Quality Control in Paper Mills," Moderator, Dorian Shainin, Quality Control Consultant, Rath & Strong Inc., Boston, Mass. Panel: John R. Lunt, Continental Can Co. Haverhill, Mass.; Wm. H. Crosier, Byron Weston Co. Dalton, Mass.; M. E. Blew, Strathmore Paper Co. West Springfield, Mass.

Dec. 12, 1958 (Roger Smith Hotel, Holyoke, Mass.): "Management Controls and Mechanization," by William Alden, President Automation Management Inc., Westboro, Mass.; "Position of the State in Stream Pollution Control in the Connecticut Valley Area," by Clarence I. Sterling, Jr., Director of the Division of Sanitary Engineering, Department of Public Works, Commonwealth of Massachusetts, and William Wise, Director of State Water Commission, State of Connecticut.

April 10, 1959 (Roger Smith Hotel, Holyoke, Massachusetts) "The Huyck-Smith Portable Felt Porosity Tester," by Hans H. Dirzuweit, Huyck Felt Co., Rensselaer, N. Y.

June 5-6, 1959 (Chatham Bars Inn, Chatham, Mass.) "New Developments in Internal Bonding of Papers," by Kenneth W. Britt, Associate Research Director, Scott Paper Co., Chester, Pa.; "Effect of Wood Fibers on Sheet Characteristics," by S. Earll Church, Jr., Technical Service Representative, Rayonier Corp., New York, N. Y.; "Unusual Opportunities in Paper Products", by Albert W. Dunning, Director of Market Research, Plastic Coating Corp., Holyoke, Mass.; "Synthetic Fibrillating Fibers—A New Tool for Manufacture and Bonding of Long Fibered Synthetic Fibre Paper," by Hanns F. A. Arledter, Director of Research, Hurlbut Pape Co. South Lee, Mass.; "High Speed Paper Formation," by E. J. Justus, Vice-President—Research, Beloit Iron Works, Beloit, Wisc.

New England (Eastern District)

Ohio

The Ohio Section was organized on Nov. 30, 1934, at Middletown, Ohio.

Indiana District (Ohio Section)

The Indiana District of the Ohio Section—TAPPI was organized at Indianapolis, Ind., in November, 1957.

Empire State

The Empire State Section began holding meetings in 1935, in Syracuse, N. Y., and received its charter on April 2, 1938. In 1943, the Section was reorganized on a regional basis with

meetings being held in four districts (Central, Eastern, Northern, and Western) of New York State. In 1948, the Metropolitan District was established.

CENTRAL DISTRICT (University Club, Syracuse, N. Y., first Friday of month).

Oct. 3, 1958: "Maintenance Organization and Problems in a Multi-Machine Mill," by S. A. Casperson, International Paper Co., Corinth, N. Y.
Nov. 7, 1958: "Drying of Paper," by A. H. Nissan, Rensselaer Polytechnic Institute, Rensselaer, N. Y.
Dec. 5, 1958: "Panel on Sizing." Panelists: H. R. Holland, Monsanto Chemical Co.; C. G. Landes, American Cyanamid; John Cochran, Hercules Powder Co.
Jan. 9, 1959: "Cost Control in the Paper Industry," by J. E. Mahon, Armstrong Cork Co., Fulton, N. Y.
Feb. 6, 1959: "Fundemantal & Practical Aspects of Microorganisms in the Paper Mill," by Robert Zabel, New York State College of Forestry, Syracuse, N. Y.
March 6, 1959: "The Magic of Color," by O. C. Holland, Interchemical Co., New York, N. Y.
April 3, 1959: Plant tour of Armstrong Cork Co., Fulton, N. Y.
May 1, 1959: Senior Night, Speaker: Ronald W. Hynes, President, Newton Falls Paper Co., Newton Falls, N. Y.
May 21, 1959: Ladies' Night.

EASTERN DISTRICT (Queensbury Hotel, Glens Falls, N. Y., third Thursday of the month).

Oct. 23, 1958: Tour of Williams Press, Menands, N. Y.
Nov. 20, 1958: "Crown Determinations in Calendar Stacks," by Howard E. Kuehn, Farrel-Birmingham Co., Inc.
Dec. 18, 1958: "Paper Industry Instrumentation," by R. E. Fishburn, Minneapolis-Honeywell Regulator Co.
Jan. 15, 1959: Executives Night. "Clupak," by Hewitt Welsh, Clupak, Inc.
Feb. 19, 1959: "Synthetics in Felts," by Dan B. Wicker, F. C. Huyck & Sons, Rensselaer, N. Y.
March 19, 1959: Junior Awards Night.
April 18, 1959: Ladies' Night.
May 21, 1959: Fourth Annual Symposium. "Beater Additives." Moderator, Vincent A. Long, Blandy Paper Co. Panelists: (1) "Elastomers," by N. H. Sherwood, B. F. Goodrich Co.; (2) "Wet and Dry Strength Resins," by J. C. Barthel, American Cyanamid Co.; (3) "Starches and Gums," by A. N. Goldstein of Stein Hall & Co.; (4) "Mill Practices," by F. R. Ramage of Latex Fiber Industries, Inc. Banquet Speaker: Fritz Rosenthal, Knowlton Bros., Watertown, N. Y. "Beater Additives and Their Future."

WESTERN DISTRICT (Prospect House, Niagara Falls, N. Y., first Wednesday of the month).

Oct. 1, 1958: "Air Pollution Control Laws as Related to the Pulp and Paper Industry," by Arnold Arch, Director of Air Pollution Control for the City of Niagara Falls, N. Y.
Nov. 25, 1958: Experiences of a Woodsman, by Paul Provencher, Ontario Paper Co.
Dec. 10, 1958: "The Old and the New of Corrosion Measurement," by a speaker from National Aluminate Corp.
Feb. 4, 1959: "Causes and Cures of Low Back Injuries," by W. F. Trelford, Thorold, Ont.
March 11, 1959: "Encouraging Student Interest in Careers in the Pulp and Paper Industry," by Tom Jones, Beloit Iron Works.
April 11, 1959: Ladies' Night.

METROPOLITAN DISTRICT (465 Lexington Restaurant between 45 & 46th Sts., Lexington Ave., New York, N. Y., second Tuesday of the month).

Oct. 14, 1958: "Foodboard—Southern Style," by Robert A. Negaard, St. Regis Sales Corp.
Nov. 12, 1958: "Nonmetal Piping vs. Metal," by Robert J. Bricmont, A. M. Byers Co. and John A. Williams, Bolta Div., General Tire & Rubber Co.
Dec. 9, 1958: Film "1104 Sutton Road," by Warren Rittinger, Champion Paper & Fiber Co.
Jan. 13, 1959: "The Paper Industry 1958–1959" by Fredric T. Grayson, Economist on the staff of the American Paper & Pulp Association.
March 10, 1959: "Coating Methods," by Harold Annis, Oxford Paper Co.
April 15, 1959: "Developments in the Printing Industry," by Ernest Schmatolla, V.P., Publishers Printing, Rogers Kellogg Corp. and Charles Shapiro, Ed. Dir., Lithographic Technical Foundation.
May 12, 1959: Ladies' Night and Annual Meeting. "Interplanetary Paper World of Tomorrow," by C. W. Kohlman American Cyanamid Co.

NORTHERN DISTRICT (Hotel Woodruff, Watertown, N. Y., second Thursday of the month).

Oct. 3, 1958: Trip to Syracuse University Wood Products Laboratory. Evening meeting held jointly with Central District Empire State TAPPI at Syracuse.
Nov. 13, 1958: "Paper Inspection," discussed by panel of own members.
Dec. 11, 1958: "Foamer & Defoamer Applications." Panelists: Messrs. Abrams, E. F. Houghton Co.; Forsythe, Nat'l. Aluminate Co.; Hall, Nopco Chem. Co.; Hammer, Socony Mobil; Ransdell, Hercules Powder Co.; Talbot, R. T. Vanderbilt.
Jan. 8, 1959: Students' Night. "Opportunities in the Paper Industry," by C. P. Donofrio, State Univ. of New York College of Forestry and Dr. Charles Howe, Clarkson College of Technology.
Feb. 12, 1959: "Corrosion Mechanics," film presentation.
March 12, 1959: "The Corrosometer" by Rod Eddy, National Aluminate Corp.
April 9, 1959: Empire State TAPPI Award Night.
May 14, 1959: Ladies' Night.

EMPIRE STATE ANNUAL MEETING (Whiteface Inn, Lake Placid, N. Y.)

June 12, 1959: "Paper Mill Cleanliness." Chairman, Gordon Rabeler, International Paper Co., Glens Falls, N. Y. (1) "The Mechanism of Growth of Bacteria and Fungi," by Donald C. Lundgren, Dept. of Bacteriology & Botany, Syracuse University; (2) "Slime and Odors in the Paper Mill," by Ralph T. Russell, Microbiological & Biochemical Research Cneter, Syracuse Univ. Research Institute; (3) "Foam Control in the Paper Mill," by D. H. Hall, Nopco Chemical Co., Newark, N. J.; (4) "Felt Cleaning—Its Effect on Felt Performance and Felt Life," by James Hanchette, Huyck Felt Co., Rensselaer, N. Y.; (5) A Clean Paper Mill—The Problem and the Solution," by Fred Crane, Crane & Co., Dalton, Mass.; (6) "Effective Microorganism Control Program," J. J. Dietzel and C. P. Kircher, Buckman Laboratories, Inc., Memphis, Tenn. Junior Award Papers. Chairman: J. J. Forsythe, International Paper Co., Niagara Falls, N. Y. Workshop Session on Paper Mill Cleanliness. Panels: (1) Bacteria, Fungi, Slime and Foam Session; Panelists—Donald C. Lundgren, Ralph T. Russell, D. H. Hall; (2) Felt Cleaning Session; Panelists—James Hanchette, Lou Ward of Huyck Felt Co.; (3) Clean Paper Mill Session; Panelists—Fred Crane, G. J. Rising of Eastern Chemicals, Inc., Rensselaer, N. Y.
June 13, 1959: "Films and Foils." (1) "Hot Melt Coatings," by F. R. Lehman, Dow Chemical Co., Midland, Mich.; (2) "Emulsion and Solvent Coating Developments," by Clifford G. Morse, Sealright-Oswego Falls Corp.; (3) "Use of Films and Foils in Combination with Paper," by Paul Wolper, Riegel Paper Co., Milford, N. J.; (4) "Metalizing Technique for Paper Combination," by K. C. Taylor, F. J. Stokes Co., Philadelphia, Pa.; (5) "The Re-Use of Plastic Coated Papers," by Ralph Kumler, Waste Paper Utilization Council; (6) "The Economic Effects of Plastics' Use on the Paper Industry," by Anthony Dragonette, Bakelite Division of Union Carbide and Carbon Chemicals Co." Work Shop Session on Films and Foils. Panels: (1) Coating Session; Panelists—F. R. Lehman, Clifford Morse, G. L. Booth of Dilts Machine Div. of Black-Clawson, Fulton, N. Y.; (2) Films, Foils & Metalizing Session; Panelists—Paul Wolper, K. C. Taylor (3) Economics and Re-Use Session; Panelists—Ralph Kumler, Anthony Dragonette.

Maine-New Hampshire

The Maine-New Hampshire Section was organized at Orono, Me., on Oct. 25, 1940, and received its charter at Bangor, Me., on Oct. 26, 1945.

Oct. 24–25, 1958. (Fall Meeting, University of Maine,): "Research Activities of the Chemical Engineering Department" Lyle C. Jeness, Prof. and Head of Chemical Engineering Dept.; "A Review of Pulp Friction Studies," by Richard E. Durst, Prof., Chemical Engineering Dept.; "Paper Coating Facilities and Research at the University of Maine," by Robert C. Chase, Instructor, Chemical Engineering Dept.; "Development of More Efficient Methods of Aeration," by Stefan A. Zieminski, Associate Prof., Chemical Engineering Dept.
June 13–14, 1959 (Annual Spring Meeting, Poland Spring House.): "The Determination of Pulp Mill Steam Plant Capacity," by F. O. White, retired, formerly with Fraser Paper, Ltd.; "By-product Steam Power" by W. E. Knight, Stone & Webster Engineering Corp.; "Air Systems in Connection with the Utilization of Heat in Paper Mills," by C. E. Blanchard, J. O. Ross Engineering; "Heat Exchange Equipment in the Modern

Paper Mills," by William Pittam, Stone & Webster Engineering Corp. A program on "Operations Research" was held concurrent with the technical program. Mr. Malcolm White was in charge of this program.

Chicago

The Chicago Section was organized as the Chicago Professional Paper Group in October, 1943. The Section was chartered in 1946.

Sept. 9, 1958: "The Corrugator Combining Operation," Panelists: Fred A. Leser, Sales Engineer, Samuel M. Langston Co. "Continuous Running Double Backer or Automatic Order Changer"; W. F. Ward, Product Manager and C. D. Nitschie, Chief Engineer, Hooper Box Machinery Dept., Koppers Co., Inc., "Evaluation of Hooper Balanced Cut Off"; Burt Mendlin, Container Production Manager, Cornell Paperboard Products, "Corrugator Operating Problems."

Oct. 7, 1958: "Skin and Bubble Packaging," Moderator: Tom Shartle, Field Engineer, Pyroxylin Products Co. Panelists: Kenneth Winrich, Project Engineer, Cornell Paperboard Products Co., "Paperboard and Inks"; Carl Schueppert, Chemist, Paper Converting & Finishing Co., "Coatings"; Kenneth Morris, Packaging Engineer, Flex-O-Glass, Inc., "Plastic Materials"; Roman Ebert, Jr., Vice-President, G. A. Ackerman Co., "Machines and Converting."

Nov. 4, 1958: "Rotagravure Printing of Boxboard." Tom Zentner, Assistant Technical Director, Diamond Gardner Corp.

Jan. 6, 1959: "Printing on Corrugated Board." Panelists: Roy P. Caponi, Plant Manager, Union Bag-Camp Paper Corp., "What's Ahead for Corrugated Printers"; J. F. Steinbrunner, Production Manager, Central Division Interchemical Printing Ink Co., "New Developments in Corrugated Inks"; Joe Sander, Vice-President, Sander Wood Engraving Co., "The Use of Woodcut Artwork for Multi-color Printing"; Joe Mazur, Branch Manager, Jas. H. Matthews Co., "Advancements in Printing Dies and Material."

Feb. 3, 1959: "New Aspects of Adhesives." Panelists: Raymond Stone, Director of Research, Morningstar-Paisley, Inc., "Why Latex Is a Suitable Raw Material for Adhesives"; John Coffey, Field Technical Service Representative, National Adhesives, "Vinyl Emulsions—Key to Packaging Efficiency"; Richard Smith, Vice-President for Research and Development, H. B. Fuller Co., "The Future of Hot Melt Adhesives in Paper Converting."

March 3, 1959: "Applications of Scotchgard to Paper and Paperboard, Its Functional Uses and Possible Markets." J. M. Thompson, Product Manager, Industrial Sales Chemical Division, Minnesota Mining & Manufacturing Co.

April 7, 1959: "Design and Research in Packaging." Ray Howard, Assistant Research Manager, Container Corp. of America Design Laboratory.

May 5, 1959: "Aluminum Foil—Laminating, Coating and Printing," James T. Trousdale, Product Manager, Laminating Division of Anaconda Aluminum Co.

St. Louis District (Chicago Section)

The St. Louis District was established in 1956.

Lake Erie

The Lake Erie Paper Makers and Converters Association was organized at the Hickory Grille, Cleveland, Ohio, on Oct. 7, 1949. The Section received its charter on May 18, 1951.

Oct. 16, 1958 (Cleveland Engineering and Scientific Center): "Motivation, Incentive and Selling Ideas" by Charles A. McBride, Bach and McBride Personnel Services, Cleveland, Ohio.

Dec. 18, 1959 (Cleveland Engineering and Scientific Center): "Aluminum Foil—Laminating, Coating, and Printing" by James T. Trousdale, Cochran Foil Corp., Louisville, Ky.

Feb. 20, 1959, Plant tour of World Publishing Co., Cleveland, Ohio (Meeting at Cleveland Engineering and Scientific Center): "Gravure Printing," by Frank Kulow of Ohio Boxboard Co., Rittman, Ohio, and "Offset Printing," by Andrew Balika of Copifyer Lithograph Corp., Cleveland, Ohio.

April 17, 1959, Plant tour of Scott Paper Co., Sandusky, Ohio (Meeting at Hotel Reiger, Sandusky): "The Clupak Story," by Thomas A. Duncan, West Virginia Pulp and Paper Co., and Lundsford Lewis, Clupak, Inc.

May 15, 1959 (Sleepy Hollow Country Club, Brecksville, Ohio): Annual Meeting and Golf Outing.

Virginia-Carolina

The Virginia-Carolina Section was organized in 1954 as the Chesapeake and Allegheny Pulp and Paper Club. It received its Charter on Nov. 1, 1957.

Sept. 12, 1958 (Covington, Va.): Tour of mill of West Virginia Pulp and Paper Co.

Dec. 5, 1958 (Jefferson Hotel, Richmond, Va.): "Continuous Cooking of Pulp,—Technical," by Reavis Sproull, Philip Morris Co., Richmond, Va.: "Continuous Cooking of Pulp—Processes," by John McGovern, Parsons and Whittemore, New York, N. Y.; "Continuous Cooking of Pulp—Equipment," by Frank C. Vaughn, Consulting Engineer, Richmond, Va.; "Black Stock Screening" by Robert W. Wagner, Continental Can Co., Hopewell, Va.; "What's New in Fire Fighting," M. M. Batzer, Philadelphia, Pa.

March 20, 1959 (Jefferson Hotel, Richmond, Va.): "Developments in Paper Machine Drives," by Otis Witworth, Paper Machine Div., The Black Clawson Co., Watertown, N. Y.; "On and Off Machine Coating," by B. E. Majani, Dilts Div., The Black Clawson Co., Fulton, N. Y.; "Importance of Quality Roll Stock in the Manufacture of Corrugated Containers," by B LaTouche, Jr., Continental Can Co., Richmond, Va.; "Importance of Communication in Industry," by M. Robert Allen, Executive Director, National Home Study Council, Washington, D. C.

May 15, 1959 (Franklin, Va.): Tour of Mill of Union-Bag Camp Paper Corp., Franklin, Va. Election of officers.

Southeastern

The Southeastern Section was organized in Macon, Ga., in 1951. It received its charter at Brunswick, Ga., on Sept. 19, 1952.

Sept. 12–13, 1958 (Roosevelt Hotel, Jacksonville, Fla.): "Kraft Pulping and Bleaching of Southern Hardwood," by R. F. Perkins, St. Regis Paper Co., Pensacola, Fla.; "Saving of Paper Mill Fibers," by Herbert A. Smith, Mead Corp., Chilicothe, Ohio; "Genetics—Its Contribution to Fiber and Paper Qualities and Yields," by Bruce Zobel, North Carolina State College, Raleigh, N. C. Tour of Palatka, Fla., mill of Hudson Pulp and Paper Co.

Nov. 14–15, 1958 (Florence Country Club, Florence, S. C.): "Glass Fiber Contribution to the Dimensional Stability of Paper," by Leslie L. Warner, Owens-Corning Fiberglass Corp., Aston, R. I.; "The Basic Principle of Kraft Pulp Production," by Everett D. Cann, Hudson Pulp and Paper Corp., Palatka, Fla.; "The Clupak Story," by Charles A. Shoudy, West Virginia Pulp and Paper Co., Charleston, S. C. Prizes presented to winners of first annual Awards Contest. First place award to J. H. Smith of Southern Paperboard Corp., and second place to J. M. Mallory of Union Bag-Camp Paper Corp. Tour of Sonoco. Products Co., Hartsville, S. C.

Jan. 23–24, 1959 (General Oglethorpe Hotel, Savannah, Ga.): "Standardization of The Jumbo Mullen Tester," by R. R. Chase and D. W. Reid, Union Bag-Camp Paper Corp., Savannah, Ga.; "Concentration of Neutral Sulphite White Liquor as a Function of Wood Temperature and Wood Moisture," by J. C. Robertson, Sonoco Products Co., Hartsville, S. C.; "The Development of the Strength of Paper," by Wilfred Gallay, E. P. Eddy Co., Hull, Ontario. Tour of American Cyanamid Plant and Herty Foundation, Savannah, Ga.

March 20–21, 1959 (Francis Marion Hotel, Charleston, S. C.): "Hydrodynamics and Papermaking," by P. E. Wrist, Mead Corp., Chillicothe, Ohio; "Reduction of Mist-type Entrainment Losses in Pulp Mills," by J. C. Thurmond and O. J. Bristow, Union Bag-Camp Paper Corp., Savannah, Ga.; "Some Qualitative Remarks on Basic Fiber Properties of Interest in Paper Strength," by Malcolm N. May, Gulf States Paper Corp., Tuscaloosa, Ala. Tour of Georgetown, S. C., mill of International Paper Co.

May 8–9, 1959 (Jekyll Island Hotel, Jekyll Island, Ga.): "Fiber Fractions and Hand Sheet Properties," by Rudolf Schmut, West Virginia Pulp and Paper Co., Charleston, S. C.; "Pneumatic Conveying of Purchased Chips at Sonoco Products Company," by J. E. Wisenhunt, Sonoco Products Co., Hartsville, S. C.; "Ventilation of Electrical Sub-stations in the Pulp and Paper Industry," by R. F. Sorenson, St. Regis Paper Co., Jacksonville, Fla. Annual social program; golf, fishing, bingo, and guided tour. Golf trophies won by Mrs. Mary H. Melton, wife of E. E. Melton, Jr., of Union Bag-Camp, E. P. Aimar of Union Bag-Camp, and R. J. Rough of Riegel Paper Corp. Fishing trophy won by Ricky Waits, son of R. T. Waits, Jr., of Minneapolis-Honeywell

Gulf Coast Section

Italian Section

Sept. 14–19, 1958, (Turin: Engineering School, Turin): Congress of the European Study Group of TAPPI organized by the Italian Section: "Coated Printing Papers—The Use of Butadiene

Methyl Methacrylate Latex as Binder," by N. D. Mac Leod, and J. H. Wilson, Imperial Chemical Industries Ltd., England; "Petroleum Waxes and Their Derivates; Their Use for Sizing, Coating, and Processing Paper," by C. N. Kaper, Fasting Jonk N.V., Holland; "A Rheological Interpretation of the Behaviour of Coating Colours Where Starch is Used as a Binder," by A. Harsveldt, Nationale Zetmeelindustrie; "Modified Starches for the Size Press and Coating," by R. J. B. Millar, Starch Products Ltd., "Paper Printability," by E. Rupp, Institut fuer Grafische Technik, Leipzig, East Germany; "Coated Papers—Their Qualities and Control," by R. S. Haven, Black Clawson International; "Acrylic Resins for Use in Coated Papers," by Hubert Wilfinger, Badische Anilin und Soda-Fabrik, Germany; "Discussion on the Paper Wetting Systems," by Mario Bonavia, Cartiere Burgo, Italy; "Improvement in the quality of Various Paper Grades Due to the Addition of Chemical Leafwood Pulps from Various Leafwood Species," by Ferdinand Wultsch, Arland Papier-Fabrik, Austria; "New Paper Mills in South America," by Karl F. Schoenemann, Voith-Heidenheim, Germany; "Drives for Paper Machines," by T. R. Brossard, Beloit International, Caracas; "Comparative Beating of Soft and Hard Sulphite Pulps in the Valley Beater," by van Nederveen, Vezelinstitut T.N.O., Holland; "A Modern Screening System for Paper Machines," by Fritz Madsen, Black-Clawson International, England; "A Study on the Carbohydratical Fraction of a Poplar Wood," by Mr. Colombo, Corbetta, Pirotta, Ruffini, Sartorio, Italy; Visit to the "Istituto Nazionale per piante da Legno" at Millerose; Visit to Cartiere Bungo Mill at Verzualo; Visit to SAFFA Co., at Magenta: Visit to the Research Laboratory of Vita Mayer Co., in Milan

Dec. 3, 1958 (Vicenza Chamber of Commerce of Vicenza): "Report on the 3rd International Conference on Groundwood Pulp Held in Quebec from the 10th up to the 12th September, and Discussion on the Topics Dealt With," by Giorgio Cerio, Cartiera Italiana, Torino; "Considerations on the Characteristics of Grinding Stones—Experiences and Studies," by Carlo Gregotti, Cartiere di Verona, Milano; "A New Grinding System," by Ing. Piero Bersano, Cartiere Burgo, Torino, with moving picture.

Jan. 19, 1959 (Milano, Art and Sciences Museum): Election of Officers

April 9, 1959 (Stresa, Hotel Regina): "Some Aspects Relating to Laboratory Testing Machines in Mills," by Adalberto Calvi and Attilio Hintermann, Cartiere Ambrogio Binda S.p.A., Milano.

May 10–31, 1959: A visiting tour to the following North American Paper Mills and Boston Congress on Coated Papers: Riegel, at Milford, N. J.; Scott, at Chester, Pa.; St. Regis, at Jacksonville, Fla.; Union Bag, at Savannah, Ga.; Bowater, at Calhoun, Tenn.; Warren, at Cumberland, Me.; Great Northern at Millinocket, Me.; Oxford and John Bolton, at Lawrence, Mass.; Beloit Iron Works, at Beloit Wis.; and Consolidated at Biron, Wis.

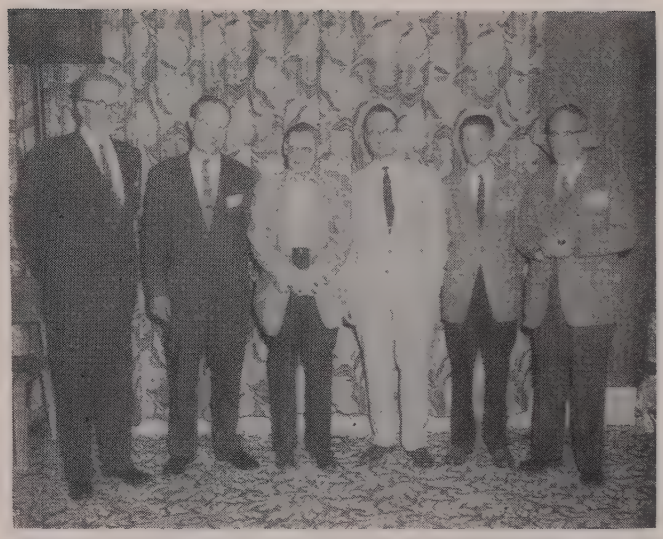
Maine-New Hampshire

Over 225 delegates attended the spring meeting of the Maine-New Hampshire Section of TAPPI at the Hotel Samoset in Rockland, Me., June 12 and 13.

The meeting started with registration on Friday morning, followed by election of officers. The following officers were elected:

Chairman: Prof. A. J. Chase, University of Maine
Vice-Chairman: C. T. Bockus, Eastern Corp.
Secretary-Treasurer: H. E. Pratt, Pejepscot Paper Div.
Executive Committee:
One year:
Edward N. Poor, Hudson Pulp & Paper Corp.
R. J. Martin, Fraser Paper Ltd.
B. A. Taylor, James A. Taylor & Son
Two years:
J. F. Wright, National Aniline Div.
P. M. Goodloe, Brown Co.
M. C. White, Oxford Paper Co.
Three years:
Don Bail, Great Northern
R. E. Perry, Scott Paper Co.
L. R. Adkins, Waterfalls Tissue
H. W. Osgood, S. D. Warren Co.

Prof. A. J. Chase, chairman of the Section, opened the formal meeting, welcoming all delegates. He then turned the meeting over to C. T. Bockus, chairman of the technical session. The first paper, "Control of Wood Losses from Stump to Paper Mill," was presented by W. F. Daniell, Great Northern Paper Co.



Technical Program Speakers: D. D. Hall, Eastern Fine Paper and Pulp Div., Standard Packaging Corp; R. C. Carpenter, Yould Paper Co.; C. T. Bockus, Earlein Fine Paper and Pulp Div., Standard Packaging Corp.; L. E. Robinson, Oxford Paper Co., N. L. Martin, Fraser Paper Ltd.; W. F. Daniell, Great Northern Paper Co.

Mr. Daniell outlined the sources of wood loss before trees are cut, during cutting, log driving, and wood preparation. Various methods of control currently employed were described and percentage losses were given for efficient operating conditions.

The second paper entitled, "Problems of Controlling Raw Material Losses in the Paper Mill," was presented by N. L. Martin, Fraser Paper Ltd.

Various steps taken to control losses in the paper mill were described. Included was a discussion of fiber losses, control of titanium dioxide use, and a description of a titanium dioxide recovery system.

Control of sizing and alum was described with comments concerning operating pH. Problems in the use of additives such as defoamers, slimicides, and pitch control chemicals were described.

The third paper "Control of Paper Machine Stock Losses" was presented by L. E. Robinson, Oxford Paper Co.

The control of paper machine stock losses is an essential factor in the production of paper at minimum cost. An effective control program requires a monitoring of losses on a routine basis.

Various methods for treating and measuring steady and intermittent losses were described.

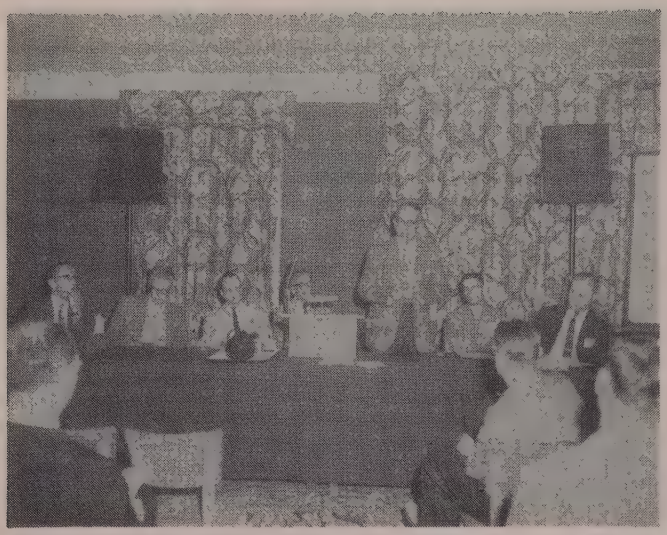
The fourth paper entitled "Control of Production Losses in the Finishing Department of a Fine Paper Mill" was presented by D. D. Hall, Eastern Fine Paper & Pulp Div., Standard Packaging Corp.

The causes for spoilage of paper from the time it is removed from the paper machine winder until it is loaded for shipment must be established. Production scheduling and planning of finishing operations are essential in holding production losses at a minimum. The importance of well maintained equipment and of the human element were discussed.

The fifth paper, "PermaWeb—A Complete Web End Break Control," was presented by R. C. Carpenter, Gould Paper Co.

A discussion was held on the application of the Curtis Wright PermaWeb on a paper machine. This instrument is a series of photocells which detect breaks and actuate water jets to restore the web. Recent trials have indicated that the apparatus is capable of arresting and restoring about 90% of the wet end breaks.

The Industrial Engineering and Material Handling program was under the direction of M. C. White, Oxford Paper Co.



Technical Program Panel: A. W. Pinkham, Curtiss Wright Corp.; D. D. Hall, Eastern Fine Paper and Pulp Div., Standard Packaging Corp.; L. E. Robinson, Oxford Paper Co.; J. J. Thomas, S. D. Warren Co.; W. F. Daniell, Great Northern Paper Co.; N. L. Martin, Fraser Paper Ltd., R. C. Carpenter, Yould Paper Co.

Industrial Engineering Panel: E. B. Denton, Keyes Fibre Co.; M. White, Oxford Paper Co.; S. Bryant, Field Machinery Co.; L. Pearson, Southworth Machine Co.

The first paper, "Southworth Lift Table System of Trimmer Operation," was presented by Leslie Pearson, Southworth Machine Co.

Movies of the equipment were shown and discussed. The equipment is reducing the shrinkage and increasing trimmer production by putting paper where it belongs at the right time and with a minimum of effort.

The second paper, "An Incentive Payment Plan for Paper Machines," was presented by E. Christensen, S. D. Warren Co.

The paper machine incentive plan is designed to provide ample earning opportunity in return for increased production of better quality paper. An outline was given of the factors involved in establishing incentive rates and methods used to adjust the rates to varying conditions of operation.

The third paper, "LP Gas as a Fuel for Material Handling Equipment," was presented by E. B. Denton, Keyes Fibre Co.

Some of the advantages by LP gas (propane, butane, or a mixture) for lift truck operation were given as: (1) Possible fuel saving for large operation, (2) Low maintenance costs, and reduction in exhaust odors.

The fourth paper, "Handling Paper Mill Materials with Lift Trucks," was presented by Sumner Bryant, Field Machinery Co.

A film was shown on Hyster trucks entitled "Handling Newsprint Aboard Ship." Action shots of the Hyster 30 lift truck were shown. Advantages of the Hyster truck were given as: reduced damage to rolls, tighter storage. A discussion was given on the new cascade clamp and the Monotrol lift truck, newest of the Hyster line.

On Friday evening a banquet was held. Professor Chase introduced R. G. Macdonald from National TAPPI and Eugene H. Clapp, president of Penobscot Chemical Fibre Co.

The very interesting and pertinent address by Mr. Clapp follows:

"Mr. Chairman, officers, and members of the Maine-New Hampshire Section of TAPPI, lovely ladies, and guests:

"I am very pleased to have been extended the honor of briefly addressing you this evening.

"How much longer can businessmen afford to just be businessmen? How much longer can you and I, with our wealth of knowledge of our American Free Enterprise System and how it ticks, sit idly by and see our heritage stolen away from us? How much longer will it be before our priceless inheritance that has been handed down to us by our forefathers becomes a mess of potage? Every day that we procrastinate or temporize means that the socialists and communists and their ilk have stolen another march on us and brings the day of our rude and probably an unfortunate awakening on, at any increasingly rapid and accelerating pace.

"All of us in American industry, as its tempo has swelled in the past half century, have had more and more business problems. Our companies have required more and more of our time and thus we have had less and less opportunities for community service or equally important, for keeping up with our ever changing political system.

"When we go back to the start of our country and to the men and women who dared to brave the wild Atlantic in small vessels, and then to set out into the forest and rough terrain of primeval America, in order to make new homes and to conquer new frontiers, we find people who not only were interested in their own personal problems, but also in the problems of their neighbors and their country. When a new neighbor moved in or a fire destroyed the home of friends, everyone in the community turned out to erect a new homestead. Our ancestors also took not merely an academic but a positive day to day personal interest in politics, education, rights of man—in fact every facet of what we consider as our priceless American legacy. No problem, no matter how small that effected their freedoms and rights, was too small to be ignored. They realized (as it sometimes seems that we apparently have forgotten) that the job of preserving our freedoms is a never ending vigil. George won't do it, or at least the kind of George that I trust doesn't seem to be doing it. All of the Georges, your friends and mine, as well as you and I, have too much of their waking hours occupied with their normal every day occupations. Not that I do not consider attending to one's job as not being very laudible, but I wonder if we have not become too preoccupied with our mundane occupational pursuits and forgotten that some of our waking hours should be devoted to protecting our freedoms by taking a greater interest in our communities and more particularly in our states and the nation at large.

"Nearly 20 centuries ago in Bethlehem in Judea was born a babe named Jesus. Now whether you believe he was the Son of God, as I do as a Christian, or merely a great prophet as do the Hebrews and Mohammedans, is not a question for argument this evening. The point I wish to make is that there, at that time in history, appeared an individual who

E. H. Clapp, Penobscot Chemical Fibre Co., Speaker at the Friday night banquet. In the background, Mrs. Bockus, Mrs. Clapp, Mrs Chase and A. J. Chase of the University of Maine

created a spark and who so appeared to a small group of men that they were willing to carry and spread his message far and wide, despite threats, abuses, stonings, martyrdoms, and even crucifixions. Here was an appeal to men's minds that made them willing to overcome all odds and to dare to travel in foreign countries and in all sorts of strange and frightening places to spread the message. Many men carried on this work in addition to their normal pursuits, while many more gave up everything and dedicated themselves solely to this occupation. They believed in the message that they carried and were willing to sacrifice their lives, their families, and their jobs, for their beliefs. Without such dedicated people, Christianity could never have spread as it has over the face of the globe. The same story applies also to Buddhism and Mohammedanism.

"When you turn your eyes to the founding of our own nation, an identical story, but with some changes, appears. The founders of this country, many of whom were among the upper strata of wealth and position, thus having the most to lose if their efforts and ideas were unsuccessful, were willing to chance not only their wealth, but their lives themselves, in order to promote and bring to fruition the ideas in which they believed so strongly. If the revolution of the 1770's had been put down by Great Britain and thus been turned into a mere rebellion, its leaders such as Washington, Adams, Hamilton, Jefferson, and many others, would not only have been deprived of their worldly assets, but at the worst, would have been incarcerated in prison for a substantial time, if not in fact, lost their very lives themselves. These men put their human existence as well as their worldly wealth on the line, knowing full well what would ensue if they were not successful. Most, if not all, of these individuals were already in positions of prominence in the various colonies, and they could have continued a comfortable existence for themselves and their heirs, without lifting a finger to uphold the truths in which they believed so strongly. They dared to do something, and as a result, their descendants and all of us have benefited, and thus for 150 years and more, we have enjoyed the fruits of their labors. I suggest to you, ladies and gentlemen, nay I do more. I state unequivocally that we can no longer afford to sit back comfortably and think that now and forever more we can rest on the results of the trials and tribulations and successes of our revolutionary forebears.

"People outside the United States often pointedly, sometimes facetiously and sometimes sneeringly, point out that Americans make a fetish of making money. Even accepting this premise, which I do not for a moment do, what has been the end result on the mores and character of the American people? We are certainly a religious country with few aetheists or agnostics, and one of the stars in our crown is that of granting equal rights to all beliefs. We do not show our religious feelings superficially, but the strain is strong and deep seated. We are also the most open handed nation on the face of the globe. The results (not always happy ones of course) of the expenditures of our tax moneys all around the world are apparent in many places. The numerous examples over the years of Americans springing up with money and clothing and supplies to aid disaster areas, wherever they occur in the world, are in plentiful supply. We are certainly not money-mad to the exclusion of the needs of our foreign friends, and even sometimes, of our enemies. If we are money-mad, which I deny, more power to us. The fruits of our labors speak for themselves and are visible over the face of the earth to friend and foe alike.

"However, I feel strongly that most of us, whether in business or government, have lost sight of one of our fundamental objectives. We are all interested in the matter of making profits, and that is the main goal for businessmen to keep in view. When businesses make profits, they pay taxes, they pay dividends to provide a reasonable return to the people who invested the original money to provide the goods and services. They keep people employed. But above all, they plow back the remainder of the profit into the purchase of new tools, new services, inventions, and research—all of which increase the well being of America as well as the world at large, but we as businessmen, educators, scientists, and citizens, have lost sight of the fact that doing a good job in business and in the professions is not sufficient.

"Mankind needs a goal! We all should have objectives toward which we strive—set high enough so the prize is not too easy, but for most of mankind not set so high the ultimate objective cannot be reached. Only a few are brave enough to strive a lifetime through toward the unattainable.

"More and more, it seems to me, people of America are allowing the Federal Government to intrude upon their personal freedoms and to embark on a new system of protection from the cradle to the grave. I fear that there are too few Americans who realize that such a system weakens the spiritual and moral fiber of our young people. A too sheltered individual is a weak individual. The more we are all protected by the Great White Father in Washington, the less we have to rely on our inner strengths, and the less we have to work to obtain a goal. Thus in my opinion, the ultimate conclusion would be that, except for the bureaucrats in Washington, the rest of the people would be no better than animals with no will to do more than exist. God gave every man a mind and reason, and no man should be deprived of this God given heritage by having someone else do all his thinking for him.

"Is it for this that our forebearers bled and died at Valley Forge and San Juan Hill and the Argonne and our brothers and friends at Cassino and Iwo Jima and Inchon? Is it for this that the pilgrims and others braved the icy wide Atlantic, or our ancestors the hot plains of Kansas, and the icy peaks of Colorado. Do we work long and hard only so that our sons and their sons may sit at ease without worries or cares or chances to think and dare to try to conquer the

unknowns of the future? To smooth the way—yes. To give chances and opportunities that we had not—yes, but to remove all incentives or challenges or opportunities to scale new heights—perish the thought. What profit is there for those who follow if they gain the easy life, but lose their souls to inertia and no challenges?

R. S. French, Keyes Fibre Co.; S. Holway, Solvay Process Div., Allied Chemical and Dye Corp.; E. K. Nissen, Solvay Process Div., Allied Chemical and Dye Corp; E. N. Poor, Kennebec Div., Hudson Pulp and Paper Corp.

"And now, I come to my central point. The entry of businessmen into politics is a matter for enlightened self interest. Who will protect the interests of business otherwise? Labor leaders? Farmers? Educators? Lawyers? Not a chance. They have their own interests to protect. Much of politics represents a 'You vote for this for me, and I'll vote that for you.' Conciliation—yes. Practical—yes. There are very few selfless individuals who will protect the general good at the expense of themselves. Unfortunate—yes, but true.

"Businessmen must take an interest in politics not only to protect their businesses, but also to protect the freedoms and rights of all our citizens. If businessmen do not soon aspire to and take an active interest in local and national politics, our economic system will eventually be doomed, through inaction if nothing else.

"Too many of us, in fact the large majority, are operating under a great illusion. We feel that as businessmen doing a good job we should merit the respect of the American public, but more is required of us than merely doing a good day to day job in our various occupations.

"Businessmen must take the time to personally meet with their representatives, not only local but state and national. We must build up a personal acquaintanceship by having, for instance, lunch with him in the off season, or inviting him to the plant or store or office, take the time to congratulate him personally face to face when he wins an election or votes right (your way of course). In this way you become a face, a real personality, not an impersonal, unknown, individual. Then when later you do write or phone, the impact is of real importance. The profit that comes from such personal contacts is immeasurable. It is tangible, and the results are felt by both sides.

"The success of our businesses in our various communities is the bulwark and main support of our free enterprise system. Thus a healthy, business climate makes a healthy prosperous America.

"But this is not the only facet that should be interesting business people. Our other basic freedoms as outlined by the Constitution and the Bill of Rights, are being constantly chipped away little by little by those who would like to impose another economic system in our country. If business people hesitate much longer in taking their rightful place in the political arena and in taking a strong interest in protecting not only the American free enterprise system but also our personal rights as citizens. The strong trend towards socialism will not be stopped and the tide turned back, but will continue to accelerate in a geometrical progression as time goes by.

"Thomas Edison believed that luck or chance had no part in a man's success, and once said 'I never did anything worth doing by accident, nor did any of my inventions come by accident. They came by work.'

"I therefore respectfully suggest, ladies and gentlemen, that the time for talking and thinking and complaining has passed, and that the time for action is here. Let us take off our coats and get out of our easy chairs and get into the firing lines to protect our basic freedoms and rights. If people all over the United States like those in this room do not do this job, no one will. There is a tremendous job to be done, and the time is now."

Dancing followed the banquet and the evening activities were concluded with a midnight snack.

On Saturday morning panel discussions were held by the two groups—technical under direction of J. J. Thomas, S. D. Warren Co. and industrial engineering directed by M. C. White, Oxford Paper Co.

In a technical session, the Friday afternoon speakers gave a summary of their papers. A lively discussion followed on wood handling, wood yields, fiber losses, sewer samplers, such as Parshall flumes, DeZurik, vacuum operated and paddlewheel types. The PermaWeb was discussed at length in addition to electronic instruments for detecting sheet defects. Experiences were given on the use of retention aids, such as Separan, in white water recovery.

In the industrial engineering panel, further details were given on the incentive plan at S. D. Warren which has been in operation for four months. The reaction to the plan by the employees has been good.

There was a discussion on lift trucks, capacity, floor requirements, use of blinkers, and LP gas versus gasoline.

Following the panel discussions a buffet luncheon was held in the main dining room.

The golf tournament was canceled due to weather.

On Saturday evening the sports dinner was held and prizes were awarded.

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Control of Wood Losses from the Stump to the Paper Mill—Abstract

W. F. Daniell

Wood Losses Before Trees Are Cut

Fire. Fire causes wood losses that are serious, not only because of the actual wood destroyed which was growing on the land at the time of the fire, but because future growth is delayed for a long period of time. At the present time, fire losses are much less than in the past due to modern methods of quickly locating small fires and modern means of transportation and communication which can land a firefighting crew quickly in the area of the fire.

Loss of Wood by Insect Damage. In the past there have been serious epidemics of spruce budworm which killed large stands of spruce and fir pulpwood. At that time, there was no means of combating the epidemic. Recently, a serious outbreak of spruce budworm was controlled by spraying the infested areas with DDT by airplane and the damage confined to small areas.

Overmature Stands. Overmature stands of pulpwood which are not being cut result in deterioration of some of the trees as well as loss of new growth which might take place if the stand had been cut. Improved transportation methods and better knowledge of standing timber available by means of aerial surveys has resulted in improved long-range plans for rotation cutting of all timberlands which results in increased growth.

Selective Cutting. In the past, selective cutting of the most desirable species resulted in an increased stand of the inferior species. At the present time, the cutting of hardwood together with the softwood will maintain the original stands with the higher percentage of softwood.

Wood Losses During Cutting Operations

Limbs. The limbs are wasted in normal lumbering operations. The average city dweller who visualizes timberland trees as similar to shade trees may think this is a substantial loss. Actually, the volume of wood in the limbs of timberland trees is very small. To date, no practical use can be made of the limbs as there is no way to remove the bark or to handle them in an economical manner.

Tops. In normal pulpwood operations, the felled tree is cut into 4-ft. lengths starting from the butt end. The usual practice is to trim the top of the tree at about 3-in. diam. When the tree is cut into 4-ft. lengths a short piece remains. If this piece is less than 3-ft. long it is usually left in the woods as waste. While some efforts have been made to pick up and use these short pieces, in general, the cost of handling them separate from standard wood lengths has not made it economical to do so.

Stump Height. Until the advent of the chain saw, continual close inspection was necessary to make certain that pulpwood cutters working with bucksaws would cut the tree close to the ground. Much extra work was involved due to the larger diameter close to the roots and the uncomfortable position required to saw at a low level. With the use of chain saws it is much easier for the pulpwood cutter and stumps are cut closer to the ground.

Swamping Roads. In the past, a larger percentage of wood was cut and piled at the stump. It was necessary to cut roads to every pile of wood and there was substantial loss in the cutting of small immature trees in doing this. At the present time, a larger percentage of the wood is yarded out onto main hauling roads. This results in less damage to the remaining timber stand.

General. In some areas, tree-length logging can be used and the whole log brought to the mill. This eliminates the loss of the top but is not the economical way to operate in many areas.

Russia reports whole tree logging in some areas. In this case, the tree, limbs and all, is transported to a central point. The limbs are cut off and used as fuel for a steam-electric plant which provides power for sawing the trees. A report on this logging method admitted that there was considerable damage to small growth on the land when the whole tree is hauled through the remaining growth on the land.

Log Driving Losses

Sinkage. Up to 6 or 7% of pulpwood may be lost by sinkage on a long drive, especially if the wood is held in the water a second year. This loss can be reduced if the wood is seasoned before being placed in the water and is, of course, reduced if the wood is kept in the water for only a short period of time.

Lost Wood. In driving, an effort is made to keep all wood confined in the main channel and inside booms to prevent its going into swamps. Occasional high water will float wood into swamps where it may be impossible to recover all of it.

Towing. In many operations, it is necessary to tow wood across large lakes. In case of high winds while booms are being towed some wood escapes from the boom. Salvage operations recover some of this wood but a certain percentage is lost.

Delayed Drives. At times, due to low water or lack of manpower, a drive is "hung" or delayed until the following year. Under these conditions there is loss of wood due to rot and the action of worms.

The over-all loss of wood on driving is difficult to determine exactly but the average pulpwood drive will deliver to the mill at least 95% of the wood which was put into the drive.

Wood Preparation Losses

Barking. As the wood is used at the mill, the bark must be removed and for chemical pulp the wood must be chipped. In the past, there have been wasteful methods used to remove the bark. Losses of wood fiber up to 10% resulted when the old-fashioned knife barker was used. Present-day practice is to use barking drums or hydraulic barkers. With this equipment wood losses due to brooming of the ends of the sticks or abrasion from the surface results in losses which should not exceed 1%.

Chipping. Chipping of wood results in production of a certain percentage of sawdust. With dull knives and old-fashioned chippers this loss might be as much as 4%. With modern design chippers and careful attention to knife sharpness this loss can be held to less than 2%.

Sawing. In the past, most groundwood mills used 2-ft. grinders and the wood was cut to 2-ft. lengths by means of a slasher saw. This type of circular saw resulted in approximately 1/2-in. kerf. The use of 4-ft. grinders eliminated the need of sawing pulpwood. The 1/2-in. saw kerf resulted in a waste of 1% of the wood. In a mill grinding 200,000 cords of wood a year this was a loss of 2000 cords or over $50,000 based on a conservative value of wood.

Pulp Yield. The yield of pulp as a percentage of the wood used can vary from 40% for some highly bleached chemical pulp to 97% for an efficiently produced groundwood pulp. The end use of the pulp determines what method must be used. In the past 5 years there has been a rapid increase in the number of mills going to high yield sulphite for use in making newsprint. The high yield sulphite process, which uses refiners to complete fiber separation from partly cooked chips, has resulted in increasing the sulphite yield from 45 to 65%.

Pulp Mill Fiber Losses. In the pulp mill, certain fiber losses are unavoidable but good design and careful operation keeps them at a minimum. At this point we will merely list these losses as other speakers on the program will discuss in detail methods of control: groundwood mill grinder shims, bull screen losses, knotter rejections, fine screen tailings, centrifugal cleaner rejections, white water losses from gravity

and vacuum thickener effluents, tank overflows, and occasional cleaning.

Chemical Pulp Mill Losses. Knots and uncooked chips, fine screen tailings, blowpit drainer bottom losses, white water loss from thickeners, minor loss from foam overflow, and tank cleaning. The above-mentioned losses can be minimized by use of refiners on the knots and tailings which will produce an inferior dirty pulp which can, however, be used for making a lower grade of paper. White water losses can be held at a minimum by a well designed efficient saveall system.

Problems of Controlling Raw Material Losses in the Paper Mill

N. L. Martin

A PRIME objective in the operation of any paper mill is to manufacture a product of given quality in the most economical manner possible. Such an objective can be carried out through efficient utilization of manpower, machines, and raw materials.

This discussion will deal with the utilization of raw materials and some of the problems related to controlling their losses. Experiences reported are based on observations made in an integrated paper mill with six fourdrinier machines producing about 600 tons of bleached papers and groundwood specialties daily.

In addition to the economic objective involved in controlling raw material losses, the need for reductions in stream pollution has directed more rigid supervision over wastes in mill effluents. By losses, we refer to materials leaving in white water from mill discharges, losses through excessive furnish, or mill use under improper conditions.

Any organized control program requires detailed raw material data. Before any successful attempt can be made to control losses, we must know what we use and we must measure our losses. This can be accomplished by daily and continual maintenance of furnish records indicating when, where and how much of each raw material is expended on every grade.

In a beater room where raw materials are furnished manually, difficulty is sometimes experienced in maintaining accurate furnish records. For this reason, a monthly comparison between inventory records and furnish records is needed to police the methods for raw materials addition. It has been possible to correct variances noted between inventory and furnish records through improved methods of beater addition. An example of this is the use of variable speed metering pumps and/or rotameters for continuous wet end addition of starches, defoamers, slimicides, wet strength resins, etc. This has replaced, in part, manual addition at the beaters.

White water loss data are obtained daily by continuous sewer sampling and flow measurements. Parshall flumes for flow measurement are used on sewers servicing each two machines. Mechanical savealls on all machines are checked through routine testing of their clarified water. Other special flow and solids tests are carried out whenever necessary.

Thus, as described, a history of raw material use, sewer losses, and saveall operation plus flow data provides some of the information necessary in controlling losses. Specific mill problems which arise in the control of certain raw material from which a significant loss can be experienced are mentioned separately.

FIBER

Since fiber is the major item of raw material used, a great deal of effort must be directed toward minimizing fiber losses. White water handling, of course, greatly affects fiber losses. Each mill may have its own particular plan for white water systems, however, the principle of spilling the least and lowest solids white water to the sewer through proper white water processing and routing should be the main objective.

In attempting to accomplish this objective, each of our machines is equipped with drum or disk-type mechanical savealls for the clarification of machine white waters. The savealls serve a dual purpose. They lower the spill water solids and provide a source of shower water other than fresh water.

In an integrated mill the use of slush pulp to the beater at about 4% consistency involves the discharge of 350 g.p.m. of machine water for a 100-ton-per-day machine, exclusive of fresh water. It is imperative then that only the lowest possible solids be present in this spill water if losses are to be minimized.

Examples of problems related to controlling fiber losses have been as indicated:

1. Excessive rejection to sewer from 3rd stage centrifugal cleaners. Some difficulty is experienced in obtaining a reasonable rejection rate through 3rd stage cleaner orifices without plugging. To reduce or eliminate plugging the reject orifice is enlarged. This results in a higher rejection flow and consequently excessive fiber losses. A reduction in 3rd stage feed consistency to below 0.5% and regular determinations of reject losses have aided in controlling losses from this source.
2. Frequent machine changes involving washups or shutdowns adversely affect fiber losses.

These changes are not generally a controllable condition. The fiber losses, however, should be a consideration in planning the number of production changes which require washups.

3. All the factors which influence saveall operation will influence fiber losses. The goal for saveall operation should be that it handle easily the volume of machine water which must be clarified before use for showers or spilling to sewer. A suspended solids content of 0.5 lb. per 1000 gal. is considered satisfactory for clarified water.

One of the difficulties in obtaining satisfactory saveall operation has been due to increased feeds over design capacity. The increased feed being largely from greater wire cleaning showers.

FILLER

An important and probably major item of raw materials is filler.

Of the many fillers available, TiO_2 is the more expensive of common ones. Our discussion deals with the control of TiO_2 losses though the general rules for use of each filler should be similar.

The problem simply stated involves the minimum addition of TiO_2 at the beaters in an amount which will produce a sheet of specified opacity or TiO_2 content.

To determine if this is being accomplished, all production containing TiO_2 should be analyzed for TiO_2 content and weekly or periodic retention reports should be prepared. These retention reports will provide a means for checking the obtainable retentions and give an indication of losses.

Below normal retentions should be investigated and the causes determined so that corrective action may be taken. Daily sewer losses and daily inspection of machine systems for losses will aid in isolating the cause for low retentions.

On TiO_2 filled grades, machine water is handled in a special manner. No white water is allowed to spill directly to the sewer. It is collected in the machine system from the various sources such as suction boxes, suction couch and suction presses, and felt conditioners. This water is clarified by a mechanical saveall. All excess clarified water is further treated outside the machine system in a common TiO_2 recovery system.

N. L. MARTIN, Fraser Paper Ltd., Madawasha, Me.

TiO_2 RECOVERY SYSTEM

The recovery system comprises a settling tank and a high density stock filter which replaces part of the fresh water in the stock as it is received from the pulp mill with settling tank sludge. This is supplemented by a flotation type saveall which clarifies the excess water from the settling tank that would otherwise be lost to the sewer.

Instrumentation on the recovery system includes level controllers for the flotation towers and settling tank. A pH meter and amplifier with pneumatic controller regulates caustic flow to the flotation pump inlet. Size flows are adjusted manually using a rotameter.

The operation proceeds as follows:

Excess machine water at a pH of 4.3 to 4.6 and containing 5.0 to 7.0 lb. of TiO_2 per thousand gallons is pumped to the settling tank inlet. Forty to 60% of the TiO_2 present is recovered by natural settling without the use of coagulants or coagulant aids. This settled material is added to the incoming high density stock and thereby reduces the consistency from 16 to 5.0%. The settling tank effluent is treated with a 1.5% rosin size emulsion and 1.2% caustic solution for flocculation and flotation. The size dosage is about 0.5 lb. per thousand gallons of water treated, while the caustic addition is added to attain a pH of about 8.6 or other pH level at which point optimum flotation occurs.

The adjustment of pH and size dosage is accomplished through jar tests by the operators who regulate the size flow and set the pH control point on the instrument. The proper adjustment of size and caustic has been determined through experience on a trial and error basis.

Problems which can reduce over-all TiO_2 retention are:

1. *Machine Losses.* Machine losses occur from leaks and splashing around fourdrinier, defective equipment such as leaking pumps or refiners, and loss from suction pump discharges, etc. Suction pump white water losses result when white water pumps on separators will not effectively remove white water. Positive displacement pumps have been more efficient on this application than centrifugal pumps.

Frequent inspections of the machine white water system are required to reveal the many possible machine losses. Very small flows of machine white water to sewer can result in significant dollar loss of TiO_2. For example, a flow to the sewer of 1 g.p.m. around the fourdrinier amounts to about a $5 a day loss of TiO_2.

A great deal of emphasis should therefore be placed on the elimination of machine losses.

2. *Opacity Control.* To maintain paper opacity off the machine uniform and within given standards is a difficult control problem. Paper made above opacity standards results in the loss of TiO_2 through poor control of sheet TiO_2 content.

In a machine with a large white water system, we sometimes experience excessive swings in opacity from below minimum to above maximum. Variations in TiO_2 content of both broke and stock from our TiO_2 recovery system have been contributing factors in poor opacity control.

Use of a TiO_2 slurry added in the regulated stock to the fan pump was tried in attempting to reduce opacity variation. This trial method for controlled TiO_2 addition showed slightly less opacity variation than normal production.

3. *Wire Retention.* Poor wire retention necessitates higher TiO_2 concentrations in white water to obtain any specific TiO_2 content in a sheet. With a higher TiO_2 content in white waters poorer saveall clarification results and losses from any spill water increase.

The use of retention aids and pH control can improve retention.

SIZE

For mills producing sized grades of paper good control over size addition is necessary to obtain most efficient use at lowest cost.

We attempt to control size furnish from results of ink flotation tests on paper coming off machine.

To determine sizing efficiency, competitive sizes are being evaluated continually. Actual consumption and theoretical consumption on many grades are computed. Two separate size storage tanks are available so that we may store and use separately the type of size being evaluated as desired.

The sizing evaluations aid us in obtaining the size most efficient for our use. Information on relative consumption for various weights and grades of paper and the effects of beater and size press additives on sizing have also been determined.

In the control of sizing our ink flotation test results do not always indicate end use performance.

We have occasionally noted cases of skipping, feathering, or generally poor pen and ink writing even when ink flotation test results were considered satisfactory.

ALUM AND pH

Alum may be considered as relatively inexpensive when compared to other raw materials. Variations in its use, however, greatly affect sizing, color, and filler retention. These properties in turn affect costs appreciably.

The amount of alum used may be controlled by the machine operating pH desired. It appears that no general rule applies which will dictate the pH at which a machine should or can best be operated.

It is interesting to see how pH recommendations vary. For optimum sizing pH in the 4.6 to 4.8 is recommended. The pH for ideal coloring varies with the type of dye used.

For filler retention a recommendation of pH at 5.0 to 5.5 using 3% alum and possibly sodium aluminate has been suggested. For use of a retention aid, it was recommended the pH be maintained between 5.0 and 5.5 using alum at beaters and sodium aluminate at fan pump. Recommendations for sodium aluminate use has been generally before alum addition.

The operators desire a pH of 4.3 to 4.6. They believe that sticking at the 1st press and foam increases while operating at higher pH.

Consequently we have desired pH's ranging from 4.3 to 5.5 on a machine furnish containing size, alum, dye, and TiO_2. What compromise pH should we run to?

Our pH controllers in operation have aided in controlling alum furnish. About 2/3 of the alum requirements is added at the beaters while the remaining 1/3 is added to the regulated stock going to the fan pump. Sampling for the pH meter electrodes is done after the fan pump.

The pH controller accurately controls the headbox pH within 0.1 pH units when set at a pH of 4.8.

Considerable attention and maintenance is required to keep the pH meter operating accurately.

PITCH CONTROL

It is difficult to control use of additives for pitch, since no test data can accurately predict the amount of troublesome pitch which will be experienced at any given time.

To furnish some history of pitch trouble and possibly control the furnish of pitch control additives, we record the machine down time attributed to pitch. This recorded down time is largely due to cleaning spots off the fourdrinier wire.

The down time records give some indication of the effectiveness of the pitch control program. Some correlation between pitch control cost and recorded down time has been noted.

The problem remaining is how much material should be used to obtain economically the least amount of down time. Down time records do not give sufficient information related

to pitch control. Much needs to be done in establishing economical furnish levels of pitch controllers throughout the year.

Other materials which give control problems are slimicides and defoamers. On slimicides we maintain some records of slug hole frequency and wet end breaks. The method of slimicide evaluation, however, has been largely based upon inspections of the machine white water system on shutdowns. Some mills justify the control exercised through microbiological counts.

For controlled defoamer addition, some experimental work is to be carried out using probes to detect foam level in the wire pit. These probes will actuate a relay which, in turn, can operate a defoamer pump.

Reviewing briefly the control of raw materials indicates that many problems can and do exist in the mill.

An approach to the problems generally will include a program involving the collection of loss data and continual use of these data to make changes in the process which will result in reduced losses.

Supervision over saveall operation, pH control, evaluation of retention aids, and education of operation personnel in reducing raw material wastes should all help in carrying out an effective control program.

A review of some of the important problems discussed are:

1. Fiber losses as effected by cleaner rejects and saveall operation.
2. TiO_2 losses from machine white water losses. Opacity variation and control.
3. Alum use and pH control. Question of machine operating pH to satisfy sizing, aging, retention, and color requirements.
4. Pitch control. How can we determine economical levels of pitch control materials.
5. Slimicide and defoamer control. What dosages to use. Methods for controlled addition.

These control problems are only examples of those which exist in the mill.

To remain competitive as a paper mill will no doubt require the efficient use of all raw materials. Recognizing this, any mill should be able to minimize stream pollution and get maximum benefit from all the many paper additives which are available today.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Rockland, Me., June 12–13, 1959.

The Control of Paper Machine Stock Losses

L. E. Robinson

The control of paper machine stock losses is an essential factor in the production of paper at minimum cost. An effective control program requires a thorough study of each phase of the papermaking process in order to determine where improvements can be made with respect to loss, and a thorough monitoring of losses on a routine basis so that excessive losses can be detected immediately.

Paper mill stock losses can be divided into two major categories, steady and intermittent. The term "steady loss" is used to describe a loss situation, which, while not necessarily steady or constant with respect to magnitude of flow and concentration, occurs on a continuous basis. Examples of this type of loss include effluents from various types of savealls, vacuum presses, secondary vortraps, pump seal water, and leakage from various pieces of equipment around the paper machine. Intermittent losses, on the other hand, occur at infrequent intervals, and result from spills or dumps from various components of the paper machine system.

L. E. Robinson, Oxford Paper Co., Rumford, Me.

STEADY LOSSES

Savealls

The three principal types of savealls include sedimentation, flotation, and filtation units. Each by necessity must pass a certain volume of water to the sewer. This flow is approximately equal to the amount of fresh water introduced to the machine system minus the moisture in the sheet leaving the couch roll. The saveall effluent often consitutes the largest single steady loss from the paper machine system, and, if not properly controlled, this loss may reach very high proportions.

The function of any type of saveall is to separate solids from water as completely as possible, returning concentrated solids to the machine system, and providing clear water for reuse on machine showers, excess clear water going to the sewer. Each type of saveall has its particular application in the paper industry. For example, settling tanks have proved quite satisfactory for clarification of white waters with high filler contents. Tissue white waters, on the other hand, settle very slowly due to the high proportion of long fibers, and are more effectively clarified with filtration or flotation units.

It is not the purpose of this paper to discuss the relative merits of various types of saveall equipment. Assuming that the saveall is properly suited to the process, the next most important consideration is that it be properly sized. Many older mills find themselves with savealls designed for days when the machine production was much lower. Over the years the machines have been speeded up, white water flows increased, and the savealls in many cases have become obsolete. At this point a detailed study of the process is in order, with the following objectives:

1. Determine the suitability of the saveall to the process. For example, a settling tank, while normally suitable for clarification of book paper machine white waters, may be impractical because of a high frequency of furnish changes, and a resulting high inventory loss. A flotation or filtration unit might be more practical. Pilot studies should be made to determine the most suitable type of saveall.
2. Reliable material balances should be made on the saveall and white water system to determine the extent to which the saveall may be overloaded with respect to the flow of both solids and water. Every effort should be made to reuse white water efficiently. Repulping and stock dilution water requirements should always be met with white water direct from the machine rather than with saveall effluent, thus minimizing the flow to the saveall. Where improper usages of white water have been allowed to develop, minor modifications may reduce the flow to the saveall to the point where it can function effectively. The importance of wire retention cannot be overemphasized. Improved wire retention will result not only in more uniform formation, but a decrease in the solids concentration of the entire white water system. The quantity of solids to be treated by the saveall is thus decreased by whatever amount the retention of fines in the sheet is increased. Thus, reliable flow and concentration measurements are essential in evaluating the potential improvement in saveall performance.
3. With respect to settling tanks, particular attention should be given to the detection and elimination of turbulence and channeling. Reducing the inlet flow will tend to produce more quiescent conditions, but distribution of inlet and outlet flows are also important. Providing better inlet flow distribution and clear water launders for the clarified effluent may be the key to improved settling tank performance.

Press Effluents

Another steady loss which sometimes reaches quite high proportions is the press effluent. The principal factor influencing press effluent loss is the filler level in the sheet.

Press effluent solids are almost completely filler, with very few fibrous fines. Due to the presence of felt hairs and other foreign material, the press effluent cannot be returned directly to the machine system. We are presently evaluating methods for removing the contaminating material so that the recoverable material can be returned to the system. A screening system utilizing SWECO separators appears hopeful.

Stock Cleaning Equipment

Losses from vortraps, dirtecs, and other types of stock cleaning equipment are unavoidable. In order to achieve a sufficient degree of dirt removal, these units must reject a certain amount of stock. The loss from this point may be in the form of a small continuous stream, or the equipment may be dumped intermittently on a routine basis. In any case the loss is deliberate. However, every effort should be made to keep the loss to a minimum. If these units are neglected, the result may be inefficient dirt removal or excessive stock losses.

Some of the conditions which tend to cause excessive cleaner losses are improper capacity, excessive or variable swirl water pressure, and excessive bleeding from the last stage. With respect to secondary vortraps, which are normally bled on a continuous basis, dumping on an intermittent basis may reduce losses considerably with no decrease in dirt removal efficiency.

Here again wire retention plays an important role. Improving the wire retention decreases the solids concentration throughout the entire white water system. The quantity of solids potentially available for loss through stock cleaning equipment is thus decreased by whatever amount the wire retention is improved.

Leakage Around Machine

A certain amount of leakage around the wet end of a paper machine is unavoidable. If uncontrolled, however, the loss may reach appreciable proportions. Faulty deckle straps, worn gaskets, improperly placed flow deflectors and troughs are some of the points which contribute to this type of loss. An adequate inspection system will help to minimize these losses. Our experience has shown that two or three inspections a week by a trained observer will aid greatly in reducing leakage losses. His observations are reported immediately to machine operating personnel who usually correct the situation as soon as possible.

INTERMITTENT LOSSES

Some of the points in the paper mill area from which intermittent losses occur include beaters, jordans, stock chests, couch pits, stock cleaning equipment, white water systems—including headbox, screens, wire pit, piping, etc.—and savealls. The above pieces of equipment are dumped for various reasons, some of which are discussed below.

Furnish Changes

Furnish changes probably account for a higher percentage of stock losses than any other single reason, especially on specialty and book paper machines. A furnish change may necessitate dumping all or part of the paper machine stock and white water system, depending on the degree of incompatibility between the two furnishes. For example, a change from a groundwood containing furnish to a groundwood-free furnish will necessitate dumping the entire machine system, while a change in the opposite direction may not require certain components of the system to be dumped, particularly the saveall. In order scheduling, consideration should be given to the compatibility of successive furnishes with respect to fiber requirements, shade, and to the incompatibility of rosin size and fillers such as calcium carbonate. Obviously, in scheduling orders, every effort should be made to keep the frequency of furnish changes to a minimum. In some cases, additional warehouse space may be the answer to a problem of too frequent furnish changes.

Inadequate Broke Storage

Lack of adequate slush broke storage facilities is another reason accounting for a high percentage of intermittent stock losses. A machine producing slush broke at 4% consistency at the rate of 200 lb. per min. can fill a 2000-cu. ft. storage chest in 25 min. Beater room personnel have a tendency to keep their broke chests nearly full. This stems partly from the necessity of not allowing too much dry broke to accumulate around the machine and partly in anticipation of a long period of good machine operation, in which case the broke handlers might be hard pressed to supply the normal broke demand of the machine. The above 2000-cu. ft. storage chest, if 80% full, would accommodate the slush broke from only 5 min. breaking time. Obviously, during an extended period of poor operation, much slush broke would have to be sewered.

There are several ways in which a slush broke storage problem can be alleviated:

1. Create additional storage facilities. This is the most obvious solution, and also the most expensive. This step would not normally be taken unless other means of controlling slush broke losses failed.
2. Take the stock off the wire during extended breaks, thus halting the formation of slush broke. In many cases this is standard practice. However, it means stopping and starting the entire stock preparation and metering system, which many operators are reluctant to do, particularly when they are unable to foretell the length of the break.
3. Return the slush broke directly to the blend chest or machine chest during extended breaks. This is subject to the same limitations as taking the stock off the wire, except that the fourdrinier is not affected. In addition, the machine jordans must be reset to prevent overrefining of the stock.
4. Attempt to maintain broke storage chests at low levels. This will be limited by the necessity of maintaining a certain minimum level as a margin of safety and for the purpose of blending out variations in broke characteristics and consistency. Our experience has indicated that broke chest levels should be kept within the 40 to 60% full range during normal operation.
5. Develop an effective system of exchanging broke on machines with compatible furnishes. This requires good liaison throughout the beater room, and is facilitated by a large central storage chest for each general furnish classification. For example, a typical book paper mill might have central storage chests for calcium carbonate-containing broke, carbonate-free broke, and groundwood-free broke.

Maintenance and Repairs

Wire changes, felt changes, and general repairs usually involve stock losses from at least part of the machine system. If the shutdown is anticipated, the stock loss can be minimized by "running out" the machine system. If possible, the headbox and wire pit should be drained into the saveall rather than to the sewer.

Contamination of Machine System

Over a period of time the average machine system becomes contaminated with dirt, slime, pitch, and other foreign materials and has to be shut down for a wash-up, with a resulting loss of stock from whatever components are sewered. If the frequency of wash ups becomes excessive, the cause of contamination should be isolated and corrected.

STOCK LOSS MEASUREMENT

An effective loss monitoring program requires accurate flow measurement and reliable automatic samplers. At the Oxford

Paper Company we have Parshall flumes with integrating flow recorders on the sewer of each machine. The effluent is sampled in proportion to the flow with vacuum-operated samplers adapted by Oxford personnel. The effluent samplers are analyzed daily for fiber, clay, carbonate, and dissolved solids, and are reported daily to management in terms of per cent of rough production.

Such a program of continuous loss measurement is indispensable in maintaining a high degree of control of stock losses. Accumulated data help to show the magnitude of improvements remain to be made. Last, but not least, it helps educate operators to the importance of maintaining a constant vigilance with respect to the losses in their area.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Rockland, Me., June 12–13, 1959.

Control of Production Losses in the Finishing Department of a Fine Paper Mill

D. D. Hall

The first act that recommends itself is to spell out the causes for good paper to be spoiled from the time it is taken off the paper machine winder until it is loaded into the railway car or transport. The field of this investigation is fertile in specialty and fine paper finishing departments. The problem is one which plagues the operators of the most modern finishing departments. Recent visits to several new layouts have indicated that the abnormal loss of part of the paper to fill an order is one of the greatest obstacles to efficiency and customer service.

The importance of each individual operating characteristic which contributes to a production loss varies with the attitude of the supervisory staff and rank and file. The human element is a factor that contributes more toward productivity. However, if the attitude is wrong, this productivity itself may be the root of a large part of the spoilage. Suffice to say that emphasis on quality may be improved by regular efforts to increase pride of workmanship.

So that no one will think these efforts should consist of the usual poster campaign, a more specific fact to face program is recommended. In other words, the operator will be encouraged to improve the product of his labors instead of being praised for high output only. The foreman will be given the necessary cooperation from service and planning departments to allow him to improve their product as well as their production. The superintendent will be provided with good maintenance of his equipment so that he is able to spend time on leadership and the improvement in his relationships with the workers responsible to him.

Complaint meetings during which the causes for customer complaints are discussed by the man who visited the customer directly with the operators contribute useful information. However, all too frequently there is little publicity to 99.9% of the good paper which has been shipped.

Possibly, the improvement of the attitude of the average finishing department employee should not be placed first in this presentation. The point I wish to make is that if equipment is well maintained and facilities are adequate, good employee attitude can make a large contribution to the solution of the production loss problem.

The common causes of spoilage which can be reduced by improved attitude are well known, i.e., rough handling of paper, skids, cores, cutter shafts, cartons, and packages; carelessness at the cutter resulting in mixture of shades, damaged edges, and wrinkled sheets; waste of good paper slabbed off the rolls or pulled out with single sheets of defective paper; mixing of broke, off square trimming, waste at the trimmer.

This paper was studied by our friend Mr. Bockus, and at this point he suggested that ways to overcome the above mentioned rough handling, carelessness, and so forth be spelled out. There are many ways to improve the attitude of the employees concerned, and if I attempt to spell out one way, it is only done so as an illustration of one way which produced results.

This campaign was organized by the mill manager who planned to publicize the wasted dollars which occur when paper is damaged. The supervisory staff and worker representatives were together encouraged to concentrate on this phase of cost reduction at a series of meetings. At the earlier meetings it was suggested that if the employee knew how much each carton or roll of paper was worth, he would treat it with more respect. Therefore, posters were put up showing the value of paper in every common form as the campaign progressed. Case studies of certain common occurrences resulted in an improvement in attitude. By the time the concentrated campaign was reduced to a regular routine the average employee looked askance at any person or piece of equipment which damaged paper, caused rejects due to mixture of shades, damaged edges, and wrinkled sheets.

The cause of large wastage which receives the greatest publicity is poor equipment. The cold war carried on between operator and maintenance millwright is critical in some organizations. This, of course, requires summit meetings between the superintendent and plant engineer to settle each crisis. Like Berlin, the basic cause of the production loss is probably a mistake in judgment which has required constant patching up to keep going. So a vigorous program of good equipment replacement is indicated. This will overcome part of the problem caused by the equipment which the millwright proves is inadequate, overloaded, and worn out.

It will not correct the problem of poor maintenance nor is poor maintenance wholly the responsibility of the plant engineer. The planning department can schedule sufficient regular down time to allow for preventive maintenance to be done thoroughly. The operating superintendent can rearrange his operating crew working hours to allow sufficient time for the break-down repairs to be done thoroughly. Of course, the key to all good maintenance is the maintenance employee. He can have the best of tools and a stock of repair parts, but his workmanship is the major factor.

So it is suggested that opportunity to hear complaints of poor maintenance and to plan for better maintenance be regularly scheduled in the shape of regular meetings devoted exclusively to this subject. This will materially improve on the usual practice of assigning a millwright to the finishing department and leaving him to his own devices while the paper machines receive the attention of the millwright foreman and plant engineer.

Allied to the subject of maintenance is that of knife grinding and other routine operating requirements such as lubrication and wiping or dust removal. The first step to get up on a higher plateau is to set schedules for knife grinding, etc. The plant engineer should, of course, make someone responsible for following up these schedules. My experience has shown that even industrial truck inspection schedules result in very definite improvement in down time and operation. A truck that is in good operating condition can convert the operator from a careless roll gouging, skid collapsing, wrapper ripping, truck wrangler into a peaceful solid citizen. Of course, the workmanship in grinding knives with the correct bevel and making repairs is vital, but the regularity with which the work is done is the point of this paragraph.

Good facilities for the finishing room are essential. There is no doubt that an improvement in quality and/or reduction in loss is obtained from improvement not only in the quality of equipment but in the facilities in which the work is carried on. The damage caused by improperly designed material handling equipment such as fork trucks, floor conveyors,

D. D. Hall, Eastern Fine Raper and Pulp Div., Standard Packaging Corp., Bangor, Me.

etc., is very easy to understand. These factors combined with overloading of storage areas result in losses as high as seven percent. I do not say that I am recommending the expansion of storage areas by 200 or 300%. It is recommended, however, that orderliness be maintained, that aisles be carefully marked, and that very rigid control be established to prevent paper being stored in the aisles.

At this point I was asked by the same gentleman to specify pertinent improved facilities and equipment to reduce losses. Of course, all new cutter and trimmer equipment should accomplish this. However, I believe that more importance should be placed upon new clamp trucks for handling rolls, new cutter shaft equipment, new cutter floats for handling sheets, racks for storage of part pallet loads in warehouses and relocation of equipment to provide adequate in process and finished storage. If preventive maintenance fails to cope with old cutter and trimmer knives, they should be replaced. If production has been increased since the finishing and shipping areas were designed, a new layout will no doubt reduce losses, even though it is not economically possible to expand the facilities.

Another suggestion which may relieve the necessity of obtaining in-process storage facilities is improvement in the planning of finishing operations to balance production so that there is no overloading at any point.

This leads to my last point—lack of planning of finishing department operations does affect production loss. The effect of small orders is well known on the paper machine, but the remnant and straggler loss due to small orders in the finishing room can be as high as 50%. Many times the order service department is forced to process a large number of small orders to meet sales policies, but frequently the cause is back orders to replace paper that has been culled. One solution to this problem is to carefully study each order to see if it is a repeating commodity and to schedule a month's supply on each run. Of course, the limiting factor many times may be small goods in process storage and finished warehouse capacity.

At this point I have been asked to detail the steps taken by production planning to reduce production loss. So I will list the steps taken after receipt of an order to make and ship a certain quantity of one size, color, basis weight, and grade of paper.

1. The order is entered on the list of other orders for the same color and grade.

2. When sufficient orders are received to accumulate a total greater than minimum requirement, the planner places the accumulated amount on the preliminary week's schedule for the proper machine. This may be delayed for as much as 3 weeks if a previously published "color cycle" requires it in order to reduce production loss by making smaller quantities more frequently. This may also be delayed because longer runs occupy the machine for the next week, and during that week more tonnage of the particular grade may be ordered. Finally the run may be delayed if there are other factors which warrant further delay such as experimental results, installation of improved equipment to reduce loss, etc.

3. A further check is made before scheduling the run on the machine which is designed to ensure a constant daily supply of paper to the major lines in the finishing department. This prevents overloading the in-process accumulation areas of the parent size line while the cut size area is empty. Obviously this not only reduces damage in the overloaded accumulation areas but also reduces lost time by the cut size line and overtime by the parent size line.

I believe that the aspects which I have discussed in the preceding paragraphs may have seemed of more practical than technical nature. It is possible that this should be followed by a technical description of ways and means of accomplishing improvements in finishing room paper loss. This will entail the description of improvement on each type of machine and each detail of the layout which will contribute to reduction of broke. I think there are engineers who know what the improvements are that are being introduced today. However, the results along this line will require another 6 months to collect to be of any comparative value.

Another aspect of this subject which I have avoided is the introduction of mechanical sorting to obtain uniform standards of acceptance and the rejection of defective paper only. This subject has been given a great deal of attention very recently, but there is no indication that results have proved that there is a reduction in the amount of paper rejected.

In conclusion one must express the view that everyone close to finishing room operations, especially the fine paper field, arrives at after 5 or 10 years. The field of cost reduction in the finishing department is fertile. Possibly of equal importance to the man-hour saving improvements are the methods which prevent loss of paper. In other words, if there is an inherent loss of 100 lb. of paper due to an improved method which is used to handle it, which results in the saving of one man for 8 hr., it is obvious that, in view of the fact that the paper lost will be a loss of approximately $15, which only nullifies the gain on the man's wages which are also $15.

This presentation is closed with the expression of the wish to hear a paper a year from now describing the details of improved equipment and layout.

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The Curtiss Wright PermaWeb Design and Development

R. C. Carpenter

Magic eye, private eye, and break catcher are expressions which have been heard around no. 3 machine at Gould Paper Co. these past few weeks in describing the PermaWeb we have been developing with Curtiss Wright Corp. PermaWeb is the name selected for the wet end break control system to be manufactured by the Industrial Control Department of Curtiss Wright Corp.

The PermaWeb in its simplest form is a series of photo electric cells which detect sheet breaks by reflected light and actuate water jets for cutting a tail and automatically restores the web by moving a water jet or squirt across the machine. The three basic functions of PermaWeb can be summarized as detection, arresting, and restoring.

The PermaWeb system is designed for use on all fourdrinier-type machines. It is particularly suited and most advantageous to the higher machine speeds where interruption of production due to wet end breaks is very costly. Papermaking is an automatic process and is becoming more automated each year. Breaks are unscheduled interruptions and as such have no place in an automatic process. Mechanical improvements necessary to minimize wet end breaks are prohibitive in many cases. Trials on Gould's machine indicate that the PermaWeb is capable of arresting and restoring about 90% of total wet end breaks.

EQUIPMENT

Let's first consider the equipment to be supplied for a PermaWeb installation. Basically the system consists of a bridge with two traversing squirts mounted over the wire, detector beams at the couch and presses, a floor mounted console and remote control stations at the couch, drier, and reel.

Bridge. The two traversing squirts and their related operating mechanism are located in a shielded aluminum structure mounted above the wire in the area where the hand

R. C. Carpenter, Staff Engineer, Gould Paper Co., Lyons Falls, N. Y.

squirt would normally be located. This assembly is called the bridge. The traversing squirts are normally in a standby position, one located about 36 in. in from the front edge of the wire and the other the same distance in from the back edge of the wire. The squirts are traversed and positively positioned by a cable mechanism powered by a $^1/_4$-hp. d.c. motor. The power supply and controls for this are located in the console.

Detectors. The detecting elements, consisting of four photoelectric cells, light source, and optical system for light focusing are contained in aluminum beams mounted over the couch draw and after as many press nips as desired.

Arresting Jets. Two fixed water jets are located on the couch detector beam and on the press detector beams for arresting breaks. These are positioned about 1 in. farther in toward the machine centerline than the standby position of the traversing squirts.

Breaker Jet. A fixed air jet is mounted at the center of the detector beams over the couch draw. This jet is used to break the web after running the sheet up on the presses during start-up and also for breaking the web to minimize broke during a press break. The jet also aids in establishment of a smooth trailing edge after a break.

Console. The console contains two strip chart recorders and totalizing counters for recording time and number of front and back breaks.

All electrical relays, power supplies, and timers for the entire system are located in the console. Push buttons to cause simulated breaks for testing of the system are also located in the console.

Remote Control Stations. A master remote control station is located adjacent to the couch for manual control of the traversing squirt during machine start-up. As many other stations can be added as desired to give squirt control from the driers, calender, and reel.

OPERATION

Automatic Operation

For purposes of understanding the automatic operation of the PermaWeb we will assume that a break starts at the back side of the sheet at the first press. As it proceeds to tear toward the front side it is immediately detected by one of the two photoelectric detectors over the rear half of the web after the first press nip. Immediately following detection of the break by the detector, the front side fixed squirt at the press is actuated and the water severs the sheet. This action by the fixed squirt prevents the break from continuing across the rest of the sheet, thus leaving a wide tail to continue on through the paper machine.

The arresting operation is immediately followed in the automatic sequence by triggering of the front movable squirt which because of its standby position maintains the safety band or tail. The fixed jet shuts off and the traversing mechanism carries the movable squirt across the machine, widening the tail to the normal width sheet. The water to the movable squirt is shut off and the squirt returns to the standby position. In a time lapse of about 12 sec. the web has been completely restored and the system is ready to detect, arrest, and restore the next wet end break.

Along with the triggering of the fixed and movable jets by the detector, the wire washing shower turns on and remains on until the break is completely restored. The couch breaker jet is also triggered and breaks the web at the couch, thus eliminating undesirable accumulation of broke in the press section.

A front side break would be detected by one of the front detector cells, arrested by the fixed rear squirt and restored by the rear traversing squirt. In this instance the safety tail would be established on the back side of the machine and widened toward the front.

A break at the couch would be detected by one of the couch detectors, arrested by the fixed squirt on the couch beam and restored the same as a press break.

The PermaWeb may be installed on any one or all of the press sections for wet end break detection, arresting, and restoring. The system is interlocked so that once a section is triggered, the action must be completed before any other action can take place.

Manual Operation

The master remote control station contains tail—widen—narrow push buttons as well as an off—on selector switch. If for any reason the machine tender desires to shut the entire system off, he turns the selector switch to off and production can continue by using the hand squirt.

All control action such as starting a new tail and widening it occurs at the front side of the machine. To start a new tail, the tail button is depressed, thereby actuating the front side movable squirt which is already in the normal standby position. The wire washing shower is set in operation and the couch breaker jet is triggered to put the system into service. The tail is then narrowed to the desired starting width by pressing and holding the narrow button until the squirt moves to the desired location. The new tail is then fed from the couch to the press in the manner suited to the machine.

The tail is then widened by depressing the widen button and holding it until the desired width or full width is obtained. Releasing of the button will stop the widening process and the squirt will not move until the widen or narrow button is depressed and held.

As soon as the front traversing squirt has restored the sheet completely, the water shuts off and the squirt returns to its standby position. The wire shower shuts off and the system is automatically on a standby basis.

If for any reason the operator desires to narrow the sheet once the full width has been restored he must press only the tail button. This triggers the couch breaker jet which breaks the sheet back to the front side movable squirt. If a narrower tail is desired he presses and holds down the narrow button until the tail is at the desired width.

Any time the web is to be completely broken the operator must first press the tail button and then mechanically break the remaining tail. If he attempts to break the web without first triggering the tail cycle the PermaWeb will treat his effort as a front side break—detect it, arrest it, and restore it. Several of Gould's machine tenders found this rather frustrating until they learned the proper sequence. In several instances they were running the full width sheet up on a press during start up, broke the sheet by hand, climbed up on the press catwalk to clean the doctor and found the sheet continuing to pile up.

Operation—Dry End Breaks

When operating personnel observe a break in the driers or calender stack, pushing the tail button at the remote control station at the driers or reel will trigger the couch breaker and the PermaWeb will establish the safety tail and turn on the wire shower. The tail can then be narrowed by pressing and holding the narrow button. The machine tender then takes the necessary action to end or widen the tail as desired.

DESIGN AND DEVELOPMENT

The PermaWeb system of automatic wet end break control is a system which has long been needed in the paper manufacturing industry. Any equipment operating in conjunction with a paper machine must be reliable over extended periods of operation. Compactness, light weight, corrosion resistance, and easy maintenance are important requisites for a good system. Considerable thought and effort has been put forth

by Curtiss Wright Corp. and Gould Paper Co. in developing a unit which would meet these requirements.

Consideration has been given not only to problems involved in making the original installation but also to removal and replacement during wire and felt changes. Drawings of the equipment furnished as well as wiring diagrams will be available to the purchaser. Supports required can be fabricated by most mills to suit their own machine requirements. Sketches of suggested mountings will also be made available.

The prototype at Gould has a large bulky bridge which has operated satisfactorily; however, the production model will be considerably smaller, incorporating many mechanical refinements found desirable in the development process. Gould has a W. P. Evans Rotabelt mounted between the flat boxes and the couch. This leaves very little free wire area between the Rotabelt and couch so that the centerline of the bridge is only 24 in. back of the centerline of the 30-in. diam. couch. Operation has been very satisfactory under these conditions. The bridge can be moved back over the flat box area during wire changes thus eliminating a handing and storage problem during wire changes.

The unit now in operation has a two-speed traversing mechanism, a medium speed for widening or narrowing, and a fast speed for squirt return. The production unit will incorporate a slower speed for narrowing thus giving the machine tender more accurate control of his starting tail width.

All squirts are controlled by solenoid valves integral with the nozzles. This feature eliminates dripping after the squirts are shut off. The primary requirement for satisfactory operation of the squirts is clean water. Mill water often requires additional filters for the PermaWeb squirts. Fabric-type filters furnished with the PermaWeb will assure a clean source of water.

The fixed jets were originally installed with adjusting screws for positioning. It was found that their position could easily be determined and the squirts located before beam installation on the machine.

The couch breaker jet was originally installed to use water as the breaking medium. It was found that the water which adhered to the idler roll at the couch draw was of sufficient quantity to cause the web to break during the widening process. Compressed air was substituted and operation is very satisfactory.

The successful operation of the PermaWeb depends on the detector sensitivity and related electrical system. The original detector system included a transisterized power supply, Seimans-Halske relay, photoelectric cell, light source, transformer, capacitors, and resistors mounted in the detector beams. Considerable problems evolved from this equipment and its location. The Seimans-Halske relay, a very sensitive, polarized unit, stuck on several occasions, and caused cycling of the system. The beams were rebuilt with only the photoelectric cell, transformer, and light source remaining in the beam. The relays and power supply were replaced with a CyPak system mounted in the console. Cy Pak is the Westinghouse trade name for their static switching system. Static switching is being used in machine tool programing and general process control gecause of the absence of contact points. Gould has used Cy Pak in the control of a rapid cycle digester in their hardwood process with excellent results. The prototype used open contact relays in the other control circuits. Any relay used in the production unit will be of the sealed type.

Considerable difficulty was encountered in establishing and maintaining adequate detector sensitivity. Sensitivity will vary from day to day due to splashing of stock on the lenses, changing of paper brightness and color, ambient light changes as well as photoelectric cell aging, and line voltage change.

An amplifier was installed for each pair of detectors. This permits independent operation and adjustment of each detecting station. The new units will include a special voltmeter for each pair of cells to be used in standardizing sensitivity. These will be incorporated into the circuit so that detectors will be selfstandardizing.

Paper production depends to a great extent on water for stock dilution and cleaning of equipment. All machine mounted components of the PermaWeb are constructed of aluminum and stainless steel and made as watertight as possible. All access covers are sealed with gaskets and cement and no difficulty has been experienced. Beams have been subjected to the usual hosing papermakers are so liberal with and all internal parts have remained completely dry.

The Gould installation was made with neoprene, multiwire cables. This gave considerable flexibility in unit location and wiring. Conduit type wiring can be used for all wiring and suitable junction boxes will be provided. A short run of flexible cable with a water tight plug in connector will be furnished for making the connection to the bridge and detector beams.

The prototype utilized boxed channels and standard I beams for beam construction. This design produced components which were heavy and awkward to handle. Their large surface area tended to collect stock which eventually flaked off onto the web. Production units will be constructed from standard 2 in. or $2^1/_2$-in. aluminum pipe with all squirts and detectors mounted flush.

OPTIONAL EQUIPMENT

The PermaWeb controls can be utilized for a number of other operations. Press rolls can be loaded and unloaded, coating application can be controlled and the sheet can be marked with a marking fluid when wet end breaks occur. Provision may also be made to operate washing showers on the dandy roll or presses to wash the side through which the tail is not traveling. It might be desirable in some instances to operate the PermaWeb in conjunction with a draw compensator device. Detectors can also be located in the driers to break the sheet and hold a tail up to the last press in the event of drier breaks.

In conclusion, the PermaWeb is not limited to machine speed, web width, or type of press section. Installation of a PermaWeb wet end break control system on a fourdrinier-type paper machine can increase productivity through better machine utilization, reduced broke handling, and decreased overhead.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Rockland, Me., June 12–13, 1959.

LP Gas as a Fuel for Materials Handling Equipment

E. B. Denton

I HAVE been asked to discuss with you, "LP gas as a fuel for materials handling equipment." I want to impress upon you that I am not a petroleum engineer nor a petroleum salesman. I also want to inform you that my only experience in materials handling equipment, with this type of gas, has been with fork lift trucks. As I go along, I shall try to tell you of some of our experiences at Keyes Fibre Co.

First, we will review a little of what we mean when we refer to LPG.

LPG, as a fuel, is similar to gasoline in several respects. The knowledge of the combustible qualities of natural gas, to which LPG is closely related, is probably as old as most knowledge of fire. It was not until early 1800, that serious attention was given to the development of this great natural resource. Records seem to show that a start in this direction was made in New York State by the drilling of the first gas

E. B. DENTON, Plant Superintendent, Keyes Fibre Co., Waterville, Me.

well in 1820. The use of this fuel for domestic and industrial purposes, slowly developed along the Atlantic Seaboard. Progress continued during the petroleum discovery, and the developing period in petroleum started sometime in the 1850's. This activity established the final bond of relationship between natural gas and petroleum. The development of these two industries has extended throughout the country. With the petroleum industry and its historical background, from such a modest beginning, has been our greatest single industrial yield. Through the magic and progress of modern chemistry, came the power to its possessors for the preservation of all humanity, or the destruction of all humanity.

Propane, butane, or a mixture of the two, are the principal components of LPG. These two gases belong to the paraffin family of the petroleum products. They are obtained, in great quantities, from oil and gas wells and our industrial natural gasoline plants and refineries. They are separated from a variety of similar products and by compression and cooling are condensed to a liquid state. Enormous quantities of butane and propane are being produced by the petroleum industry through operations of natural gasoline plants, cycling condensate plants, and refineries. Today it is estimated that about $1^1/_2$ gal. of these products, in liquid form, are produced as a by-product for each 5 gal. of gasoline manufactured. In the old pioneer days of oil field development, the natural gases were considered a nuisance and were mostly flared off. Federal and State conservation laws now class these products as natural resources and make commercial disposal, or storage, mandatory.

LPG is a surplus product to the petroleum industry. Its components are not cut from the part of the petroleum barrel having higher market value and demand. LP gas production cost, is *much* lower, than that for gasoline. Therefore, its commercial price is likely to be maintained for a long period of time.

Both propane and butane are odorless gases and cannot be detected in a vaporized state without the addition of a strong smelling additive, which is the requirement of this product, regardless of how it is obtained, wherever the fuel is sold, therefore in using this gas as a fuel for materials handling equipment, any leak can be discovered before it becomes dangerous, in the same manner that a gas leak is detected in the kitchen of your home.

Liquefied petroleum gas is a highly combustible fuel, similar to gasoline in many respects, but possessing a much higher rate of evaporation. The rate of evaporation is so much higher that it is necessary to store and handle LPG under pressure. This characteristic is a distinct advantage for a fuel because it can be introduced into the engine in a dry state, allowing the formation of a perfect mixture with air. Since complete evaporation is always assured, there is no possibility of any vaporized liquid particles entering the engine and consequently washing the lubricant from the cylinder walls and diluting the crank case oil. The use of gasoline, additives, and other liquid fuels always produce a certain amount of crank case dilution, which not only reduces the effectiveness of the lubrication oil but being subject to heat and pressure, certain chemical build-ups are produced that are often harmful to the parts of an internal combustion engine.

LPG has a much higher octane rating than gasoline, therefore we feel it gives us better results in our operation. As a comparison of octane rating, to the best of my knowledge, low grade gasoline has up to 68 octane; regular gasoline has up to 76 octane; premium gasoline from 80 to 87 octane; LPG has from 100 to 130 octane. I hope these figures do not get me in trouble with any of the gasoline salesmen. In character LPG is halfway between gasoline and natural gas and its high antiknock quality makes it an outstanding fuel for high compression engines.

LPG is liquefied under pressure only (at temperatures of $-40°$ and below). It must be handled in a liquid state under pressure in order to obtain, after evaporation, the necessary volume of dry gas for engine operation. This liquid fuel is stored in specially constructed tanks mounted on vehicles, such as lift trucks. From the tank it is piped through a filter to a solenoid valve, then to an LPG vaporizer-regulator, which reduces the pressure of the gas and supplies heat to it. This overcomes the refrigerating action which takes place when a high pressure liquid is reduced to a low pressure gas. The regulator also meters the dry gas and supplies it to the carburetor in accordance to the engine requirements, therefore these requirements make the regulator the heart of the LPG system. The carburetor is extremely simple when compared with a gasoline carburetor. When equipped with a conversion gasoline carburetor the heavy carbon forming deposits which are in gasoline, are not present in LPG. Therefore, we have found very little carbon deposits in our engines. The lack of carbon formation is a great advantage since carbon is detrimental to effective engine operation. It acts as an insulator and prevents the normal flow of heat from the combustion chamber, resulting in loss of power, performance, and economy.

These vehicles may be adapted to use both gas and LPG by an additional solenoid operated valve and a three-way switch connected to both gas and LP valves. I must say, we have not attempted this type of operation.

In preparing to change our vehicles to LP gas we found the price was considerably cheaper than gasoline, on the average of about 10¢ per gal., providing we maintained and operated our own bulk station. We felt that this, with no more vehicles than we have in operation, would take too long to pay off for the capital outlay for us to own our bulk station. Therefore we purchase our gas from a local concern by the bottle or tank. We feel it would pay a concern with a large number of vehicles to maintain its own bulk station.

At Keyes Fibre Co. we have in operation at the present time 12 No. 4000 fork trucks. Six of these units were originally gasoline operated. We converted these in 1955 and since then have purchased six additional units equipped with the LP installation attached. We have three different makes of LPG installations on our vehicles. Regardless of the make of these conversion units or the equipment on which they are used, we find them about equal in performance and maintenance.

When we started our conversion in April, 1955, we completely overhauled our motors before making the conversion. Some of these motors have been run for 40 hr. per week for the last four years, or over 80,000 hr., without an overhaul job. Using conservative figures by automotive standards, at 25 miles per hr. this would be equivalent to 200,000 miles.

Prior to our change to LP a set of spark plugs lasted us 1 month to 6 weeks and now we get up to 1 year's operation from our plugs. Since converting we have had no valve trouble. Previous to that we had considerable valve trouble. With gasoline we changed oil and filter every 40 or 50 hr. of operation. With LP our oil change is every 160 hr. and filter every 320 hr. Gentlemen, you can see there is a great savings in oil.

We have one vehicle that runs 24 hr. per day. This motor was overhauled after 10,000 hr. When checked for wear it was found that we could use the same size piston rings and bearings. This again shows us the contamination is very low.

We also found that when using gasoline our drivers would operate at times with the choke partly open, with LP this is not done.

Our cost of LP gas versus gasoline is about the same, possibly a slight saving under the present system, therefore our consumption of gas is about the same. We find the time consumed in changing tanks is less than to fill a gasoline tank. Carburetors for LP are so simple that maintenance is practically nil.

One of the main reasons for our changing to LP was to reduce exhaust odors. Bear in mind you do not eliminate these odors completely.

When converting a vehicle, I would recommend that each motor should be overhauled unless you know it is in excellent condition. By all means, I feel the carbon from the engine head should be removed. Any reliable, good mechanic with the conversion kit and instructions can install any of the present-day conversion units. When installing these units, it is very important to check all LPG connections for leaks before running the vehicle, therefore you should open the tank valve slowly, turn the engine over once or twice, to load the system with gas. You may either apply a leak detector, or if one is not available, use a soap solution at all connections, to make sure that fittings are secure.

In summation, I would like to leave with you some of the benefits of LPG:

1. Complete fuel evaporation.
2. Closer control of air-fuel ratio.
3. Complete air-fuel mixing at, or below, air induction temperature.
4. Accurate control of mixture distribution to each induction cylinder.
5. High antiknock value.
6. Complete combustion.
7. Possibility lower fuel cost for large operation.
8. No evaporation or spilling.
9. Longer operation between major overhauls.
10. Freedom from gum, lead, and carbon deposits on piston rings, valves, and spark plugs.
11. Reduced maintenance cost on carburetors.
12. Elimination of fuel pump.
13. Fewer spark plug replacements.
14. Greatly reduced rate of oil change.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Rockland, Me., June 12–13, 1959.

An Incentive Payment Plan for Paper Machines

E. Christensen

INCENTIVE systems by their very nature affect the lives of nearly every member of a manufacturing organization. Each person has his own opinion on the values, merits, and desirability of such a pay system. In this paper, I will outline our installation of paper machine incentives at S. D. Warren Co.

This paper machine incentive plan is designed to provide ample earning opportunity in return for increased production of better quality paper. It is constructed to afford the opportunities for better earnings through good and reasonable standards to maintain maximum running speeds, and for betterment of quality and decreased waste.

The incentive plan is, among other factors, based on individual hourly rates. The principle so far as production quantity is concerned is a one for one type plan; in other words, for each 1% increase in production quantity above our standards there will be a 1% increase in earingings. The principle as far as production quality is concerned is one and one half to one plan.

Incentive rates are calculated for each different body stock on each paper machine. The rate is computed on the basis of the average speeds which can be maintained to produce a good quality sheet of a given basis weight. Average speeds are set from history of each body stock and basis weight for each paper machine. This recognizes the differences between paper machines and allows for the fact that certain types of paper have to be run at slower speeds.

Incentive rates also take into consideration trim as required on each order. A basic rate is figured for 100 lb. of paper at 100 in. of trim; if the machine is running only 50 in. of trim, the incentive rate will be twice that of the 100-in. rate per 100 lb. This calculation is made to consider every inch of trim over or under 100 in. and makes it possible for the machine crews to earn a fair bonus even though less pounds are weighed off the paper machines due to narrow trim.

A 15% machine allowance is built into the incentive rate. This allowance makes it possible for a machine crew to make 15% bonus when running at the standard speed.

A percentage allowance of 5% is built into the incentive rate to cover minor lost time delays. This 5% allowance covers all delays under 90 min.; such as order changes, basis weight changes, rinsing felts, breaks, and etc. All single incidents of down time amounting to 90 min. or more are considered nonincentive time. Base rates or hourly rates are paid for these major delays which protects the incentive money earned during running time. For example, if a machine runs for 6 hr. and the crews have made 2 or 3 dollars bonus and they have to shut the machine down for the remaining 2 hr., they would be paid their hourly rate for the 2 hr. and would not lose the bonus they made in the 6 hours. The same applies at the beginning of the tour. If they are down for 2 hr. before they start producing paper, they are paid their hourly rate for the 2 hr. and have an opportunity to make bonus for the remaining 6 hr. of the tour. This 5% has proved ample in studies which have been made. Machine crews are working harder when the machines are down to get them running again, and are able to better their earnings.

Also built into the standards is an allowance for waste which occurs before weighing at the paper machines. This allowance is 2% on fast machines and 1% on slower machines. The difference being in the methods of turning up sets. Machine crews gain incentive earnings by keeping this type of waste at a minimum.

All incentive plans, in order to be completely fair to both the company and the employees, must be calculated on salable good quality production. This is not only fair but economically sound. No company can afford to pay increased earnings if salable paper quantity goes down or quality becomes poor.

However, it is recognized that at times the waste on certain orders applied against an incentive plan may have a serious effect. For this reason the incentive rates are adjusted month by month in relationship to the yield of finished production by body stock groups. Standard yields are figured with finished weights versus machine weights for each body stock group. In other words, if there are only 90 lb. shipped out of every 100 lb. weighed off the paper machines, the standard yield is calculated as 90%.

Standard yields, for body stock groups, were set from history. We took an actual period of 10 months prior to the installation of the incentive plan and used this as our base period from which we derived our standard yields

Actual yields are figured on each previous 3-months average of finished weight versus machine weight by body stocks. The 3-months average levels the actual yield to eliminate any sharp rise or decline in actual yield figures.

Assuming that on a particular body stock the standard yield is 90% and the 3-months average actual yield is 92%, the per cent increase in yield is 2.2%. Using the one and one half to one plan for quality, we increase this percentage from 2.2% to 3.3%. Then we increase the production standard by 3.3% and this is the final incentive rate.

Should the actual yield drop to 88%, the production rate will be decreased by 2.2%.

The incentive rates for the machine tender are posted at each machine and are expressed in dollars per 100 lb. per 100 in. There are different rates for different grades and basis weights by machines.

The machine tender, or any man on the crew, can figure his bonus daily or by the hour if he so desires.

To find his bonus, the machine tender looks on the chart for the grade and basis weight he is running. With the rate per 100 lb. per 100 in., he divides this rate by the average

E. Christensen, S. D. Warren Co., Cumberland Mills, Me.

trim. This gives him a rate per 100 lb. per average trim. This rate multiplied by the pounds produced equals total earnings for the day. Base pay subtracted from total earnings equals his bonus. If his total earnings are less than his base pay, he is guaranteed his base pay. Other crew member's bonus is based on the same percentage as their base pay is to the machine tender's base pay. If the second hand's base pay is 85% of the machine tender's base pay, then the second-hand bonus will be 85% of the machine tender's bonus.

E. J. Justus, Beloit Iron Works, Beloit, Wis.

We use an off-standard rate per hour which is a 3 months average of the four machine tenders' bonus for new grades or specialty grades. This allows the machine crews a bonus where conditions are such that it is not feasable to set a standard rate.

We had meetings with each machine crew before installation of the new incentive plan, and explained the complete incentive plan to them. We told them the incentive plan was based on conditions existing at the time of installation. In other words, present equipment and present quality. As these conditions and requirements change or when any specific mechanical or material changes were made, the company would adjust any effected rate to reflect the changes. Any new rates would be designed to provide equal earning opportunity. Under no circumstances would rates be changed merely because someone is making too much money. Before any changes are made, the crews involved would be notified.

We have used this plan at S. D. Warren Co. for nearly a year. The results are very gratifying. Our production has increased and we are showing a reduction in waste and costs.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Rockland, Me., June 12–13, 1959.

New England

The Annual Meeting of the New England Section of TAPPI held at the Chatham Bars Inn, Chatham, Mass., was on June 5 and 6, 1959, and was sponsored by the Eastern District of the New England Section. Approximately 250 members and guests were present.

Four technical papers were read, and in addition, two student papers were presented by students of the Lowell Technological Institute, Lowell, Mass.

The dinner speech was delivered by A. W. Dunning, director of market research, The Plastic Coating Corp., Holyoke, Mass. His topic was "Unusual Opportunities in Paper Products."

The technical papers were:

"New Developments in the Internal Bonding of Papers," by Kenneth W. Britt, associate research director, Scott Paper Co., Chester, Pa.

"Effect of Wood Fibers on Sheet Characteristics," by S. Earll Church, technical service representative, Rayonier Inc., New York, N. Y.

"Synthetic Fibrillating Fibers—A Tool for Manufacture and Bonding of Long Fibered Synthetic Paper," by H. F. Arledter, director of research, Hurlburt Paper Co., South Lee, Mass.

"High-Speed Paper Formation," by E. J. Justice, vice-president in charge of research, Beloit Iron Works, Beloit, Wis.

STUDENT PAPERS:

"Evaluation of the Bubble Pressure Method for Testing Retention of Filter Papers to Final Precipitation," by Robert Farrow, Lowell Technological Institute, Lowell, Mass.

"Bonding Characteristics of Cellulosic Fibers in Solvents of Varying Polarity," by George Dillon, Lowell Technological Institute, Lowell, Mass.

S. E. Church, Rayonier Inc., New York, N. Y.

H. F. Arledter, Hurlburt Paper Co., South Lee, Mass.

Mr. Farrow's paper received first prize. Both students were guests of the section for the meeting.

The Annual Helen U. Kiely Award to the best all round Senior of Lowell Technological Institute voted by his classmates to receive the honor was awarded to George Dillon. Miss Kiely made the presentation.

ELECTION OF OFFICERS

Nominating Committee:

C. L. Reece, Chairman, Westfield River Paper Co., Russell, Mass.
C. C. Horch, Mead Corp., Leominster, Mass.
L. W. Crouse, Pennick & Ford Corp., Longmeadow, Mass.

Officers elected for the coming year:

Chairman: Professor John Lewis, Lowell Technological Institute, Lowell, Mass.
Vice-Chairman: Joseph A. Theriault, Continental Can Co., Uncasville, Conn.
Treasurer: Wm. T. Kirby Crane & Co., Dalton, Mass.
Secretary: P. J. Fitzpatrick, American Cyanamid Co., Boston Mass.

Executive Committee:

E. Whitman Strecker Esleeck Mfg. Co. Turners Falls Mass.; C. I. Horton Philadelphia Felt Co. Norwalk, Conn.; A. E. Hutton, Fitchburg Paper Co., Fitchburg, Mass.; C. S. Reppe, Hercules Powder Co., Holyoke, Mass.; J. D. Thomson, Northeast Paper Sales Co., Longmeadow, Mass.; P. L. Slayton, Monsanto Chemical Co., Boston, Mass.; R. N. Wiewel, Weyerhauser Timber Co., Clinton, Mass.; R. M. Talbott, R. I. Vanderbilt Co., East Norwalk, Conn.; D. P. Habib, Tecnifax Corp., Holyoke, Mass.; E. J. Ferrell, Crocker, Burbank Papers, Inc., Fitchburg, Mass.

Honorary:

Miss Helen U. Kiely, Northampton, Mass.

New Developments in the Internal Bonding of Paper—Abstract

By Kenneth W. Britt

ONE of the key factors in the properties of a sheet of paper is the bonding or adhesive force that exists between the fibers. With most papers the principal source of this bonding is that which develops between surfaces of fibers that have been beaten and macerated in water and then have been dried in intimate contact with each other. Hydrogen bonding through the hydroxyl groups of cellulose and of other polysaccharides is considered to be responsible for the existence of this bonding, and the remarkable physical structure of natural cellulose fibers plays an important part in its great effectiveness in paper.

The natural cellulosic bond has been of great usefulness in papermaking since the original invention of the process, but nevertheless it has several serious deficiencies. For example, its strength disappears almost entirely in the presence of water, it is inherently stiff and inflexible and hence strength and softness are contradictory properties in paper, and it has relatively little durability to repeated flexing.

It seems reasonable to suppose that a more complete understanding of the interfiber bond will permit advances in the quality and usefulness of paper products and in the efficiency of their manufacture.

As new evidence toward better understanding of the interfiber bond data are presented on the properties of paper that has been subjected to a high degree of heat. Also, an analysis is presented of the proportion of total fiber strength that is utilized in a variety of paper samples. It appears that present bonding techniques fall far short of utilizing the complete fiber strength.

There has long been a search to supplement the natural cellulose bonding with additives. The use of starch and glue "sizing" to improve paper goes back to the earliest times. In this search for bonding additives, a discovery of great significance was that of producing paper of high wet strength by the use of certain thermosetting, amino-plast resins. This mechanism depends upon treatment of fiber with a monomer or low D.P. polymer and completing the polymerization *in situ* after the formation of paper. In addition to being of commercial importance the process is also of considerable theoretical interest.

With this development as an example and with the rapid pace of research in synthetic polymers, it would seem that we are on the threshold of great developments in interfiber bonding. With present-day understanding of the relationship between molecular structure and physical properties, it is to be expected that we will be able to achieve a whole spectrum of special effects in paper properties by replacing or supplementing the natural bonding with selected polymers.

Effects of Chemical Wood Pulps on Sheet Characteristics—Abstract

S. Earll Church

VARIOUS paper properties to be considered in a stock furnish are grouped under physical strength, density and structure properties, chemical, optical and surface properties. Various end use requirements which result from a complex interdependence on these various factors may also affect the ultimate choice of furnish.

Among the commercially available wood pulps distinct differences in inherent qualities are due to the geographical source of the wood, wood species, type of pulping process, and extent of purification. The behavior during refining also reflects these inherent differences.

Future growth in specialty paper markets will depend on the extent to which wood pulps can be adapted to produce papers of high strength, improved dimensional stability, and lower cost.

Synthetic Fibrillating Fibers, a New Tool for the Manufacture and Bonding of Long Fibered Synthetic Fiber Paper—Abstract

Hanns Arledter

NEWLY developed fibrillating fibers of the nature of acrylic fibers, polystyrene, polyvinyl acetate copolymers, polynitrile copolymers, etc., are destined to become valuable tools in the manufacture of long fibered synthetic fiber paper of a multitude of designs and properties.

Twenty to eighty per cent of suitable highly fibrillated synthetic fibers are mixed with 80 to 20% nonfibrillating precut synthetic fibers of any kind or design like nylon, dynel, etc., or with long precut only partially surface fibrillated fibers like acrylic fibers, or fibers with surface swelling, like PVA, dispersed in water and deposited on a wire in a similar way as regular cellulosic papers are produced.

In principle, the same method of manufacture applies for these new fiber systems as used in the manufacture of cellulosic fiber flox synthetic fiber paper. The synthetic fiber flocks yield, though, improved properties in the paper and laminates, and lead ultimately to 100% synthetic fiber papers of high strength and over-all chemical and physical properties not obtainable with papers consisting of unbonded mixtures of cellulose and synthetic fibers.

The new synthetic fiber papermaking method overcomes (partially) the problem of insufficient strength of the wet or dry sheet on the paper machine and allows the re-use of wet and dry broke during the first steps of papermaking.

This paper describes properties of papers pilot plant manufactured with the new method and laminates made therefrom.

High-Speed Paper Formation—Abstract

E. J. Justus

THE speaker gave examples of high-speed machines operating on various grades of paper such as: newsprint at 2200 f.p.m.; kraft bag at 200 f.p.m.; cylinder board at 500 f.p.m.; coated Book at 1600 f.p.m.; box boards at 1400 f.p.m.

Mr. Justus spoke of formation as an index of weight distribution, and fiber orientation. He cited cases where high-speed machines were limited by poor over-all distribution of fiber, highlighting the difficult problem flocculation. He spoke of problems encountered in getting good fiber dispersion with higher consistency and the problem of water drainage from fibers. Examples were given of how longer wires have had to be used to offset low consistency required to obtain good dispersion.

Problems of streaking in the machine direction were analyzed.

Newsprint machines have jumped from 1400 to over 2200 f.p.m.—yet "highest speed machines are making the best paper, hence, haven't sacrificed quality for speed."

Several diagrams of high-speed machines were shown and discussed, including procedures used in delivering stock to the wire, formation on the wire, and means used to get lower consistency for best dispersion.

Many interesting experiments on paper machines were mentioned—including one on unsuccessful elimination of table rolls, and the corresponding information gained from this experiment on the function of table rolls.

The Beloit adaptation of the Stevens Former was described. Also discussed was the Scott suction breast former and the Inverformer. In the question period which followed, it was disclosed that consistencies as high as 1.5% and higher can be used in the headbox (Inverformer); the Inverformer has worked best with slow stocks; does an excellent job on ply bonding—plys won't separate and cannot be pulled apart.

Lake States

The fourth meeting for the year 1958–59 for the Lake States Section of TAPPI was held March 10, 1959, in Kaukauna, Wis. During the afternoon, about 150 members toured the pulp and paper mill of Thilmany Paper Co. There were 225 members present for the dinner and speech at the Kaukauna Elks Club.

Speaker for the evening was William Ingmanson, from the staff of The Institute of Paper Chemistry, Appleton, Wis. His subject was "Water Removal on the Fourdrinier Paper Machine." The subject was presented predominantly from a fundamental basis, followed by practical applications of the theory. Numerous slides made the topic most interesting and enlightening to the audience, and many questions were presented to the speaker after his presentation.

W. J. BUBLITZ, *Chairman*

Water Removal on the Fourdrinier Paper Machine—Abstract

W. L. Ingmanson

In considering the relative amounts of water removal from a stock suspension on the wet end of a paper machine, from 65 to 75% is generally removed over the table roll section. For this reason, much attention has been devoted in recent years to study of the action of table rolls in attempts to

Lake States Officers: (Seated left to right are) W. Stinger, Marathon Division of the American Can Company; R. Leaf, Shawano Paper Mills; W. Nelson, Green Bay Paper and Pulp Company; Standing left to right, R. Bender, Appleton Machine Company; and W. Bublitz, Kimberly-Clark Corporation

quantitatively characterize the relation between fiber and machine variables in this filtration operation. The purpose of this presentation is to illustrate and discuss some specific examples of how studies of water removal have been used for control, operation, and design problems. One approach is to consider rate of drainage from the wire as being equivalent to a driving force divided by a resistance. Recent studies by Taylor and Wrist have shown the magnitude and distribution of suction developed in the table roll nip. Laboratory determinations of filtration resistance of pulp slurries can be made and then related to paper machine drainage. Examples are given of problems of estimating wire length, over-all table roll drainage as influenced by machine speed, and the effect of headbox consistency and stock temperature on drainage rate at different speeds.

Finally, it is shown how fiber properties affecting filtration resistance can be determined. The influence of swollen fiber specific volume, specific surface, and flexibility on such problems as dewatering, wet web strength, drying rate, and final dry sheet properties is discussed.

Delaware Valley

The May meeting of Delaware Valley Section of TAPPI was held at Hercules Powder Co. Country Club, Wilmington, Del., on May 22, 1959.

The program included golf in the afternoon followed by a social hour and a wonderful dinner.

The subject of the technical program was "Food Additives" presented very excellently by Robert C. Stanfill, Chief, Philadelphia District Food & Drug Administration, U. S. Department of Health, Education andWelfare.

L. H. Smaine, *Secretary*

Food Additives

Robert C. Stanfill

It has been said about speeches and sermons that the best ones are brief. A professor told his student ministers, "If you don't strike oil in the first 20 min., stop boring." I'm sorry I do not know all the answers well enough to confine myself to brevity.

Unfortunately, the invitations to Commissioner Larrick, Deputy Commissioner Harvey, and Dr. Arnold J. Lehman have been so numerous that they cannot appear on all the programs they would like. I do not pretend to know as much about the application of the Food Additives Amendment to your particular problems as they do. I am glad to have this opportunity to get better acquainted with you and I hope I can bring you some of the message that the Commissioner would bring if he could meet with you tonight.

The Food Additives Amendment enacted last year, requires the person who wants to promote an additive to test it for safety on animals and submit results of the safety tests to us. Our scientists will study the safety data and reach an independent decision as to the suitability of the new ingredient for use in the food supply. If the evidence clearly demonstrates that the material is an appropriate component of food, then we will issue a regulation stating safe permissible uses for it. But if there is a question as to its safety, we will not allow it and the public health will be safeguarded in a way that has not been possible heretofore.

We cannot sanction a use of an additive that promotes deception of consumers. If the additive is one whose concentration in food must be restricted to safeguard health, the law requires us to allow only the quantity needed to accomplish the intended technical or physical effect and of course this quantity will be allowed only if it is safe. We cannot consider as safe any additive which is found to induce cancer when ingested by man or animal or which is found after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal.

The law does not require testing of old food ingredients, that is, those in use before Jan. 1, 1958, provided appropriately qualified experts generally recognize that the uses being made of them are safe. But old ingredients whose safety is not thus generally recognized must be tested in the same manner as new additives. The old ingredients are allowed a transition period during which any needed safety testing may be conducted. New additives were required to meet the full requirements of the new law by March 5 of this year.

There are many complex problems to be worked out by government, industry and others concerned with the use of food additives. We believe that the best way to get this law into operation with a minimum disturbance of all concerned is by continuing the long-standing open-door policy of the Food and Drug Administration. We are always ready to consult with industry or consumer representatives on the application of the law to their problems, and have held numerous conferences already.

Several petitions have been submitted formally requesting approval of food additive uses, and over 100 have been discussed with us informally. One regulation has issued under the new law authorizing use of an antioxidant in feed for poultry and other animals to retard the destruction of certain nutrients during storage.

The Food Additives Amendment of the Food, Drug, and Cosmetic Act is one of the most significant legislative developments in the food field since the basic pure food and drug law was modernized 20 years ago. It is a far-reaching step which gives the American consumer a greater guarantee of

Robert S. Stanfill, Chief, Philadelphia District, Food and Drug Administration, U. S. Department of Health, Education, and Welfare, 1204 Custom House, Philadelphia 6, Pa.

safe food than he had before. With adequate funds to administer it, with the same type of close cooperation that we have received for years from outside groups such as yours, with continuing public support, we will put this law into full operation monthly.

Arthur A. Checchi, assistant to the Deputy Commissioner appeared before the Industry Conference on the Safety of Packaging Materials, sponsored by the Packaging Institute, in New York on March 3, 1959. He spoke on the procedural requirements of the Amendment from the administrative standpoint. He was followed by L. L. Ramsey of FDA's Division of Food. Mr. Ramsey covered some of the scientific aspects. Deputy Commissioner John L. Harvey spoke before the National Paper Board Association at White Sulphur Springs on Tuesday of this week.

My discussion will quote freely from the remarks made by Mr. Harvey, Mr. Checci, and Mr. Ramsey because they stressed the points that are particularly applicable to food packaging materials.

I recommend for your study Vol. 14, no. 1, *Food-Drug-Cosmetic Law Journal*, January, 1959, which published FDA's answers to questions submitted at the Washington Conference on November 24–25 to discuss the 1958 Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act. But let us get down to consideration of the fundamental requirements of the Amendment with respect to their application to food packaging materials.

The Amendment establishes a formal system for dealing with food additives, but this does not involve any new basic procedures or concepts that responsible members of the affected industries have not already been observing. Surely no one questions the wisdom of requiring that any substance added to food either directly or indirectly should first be shown to be safe for such use. That is what the Amendment seeks to accomplish.

A person wishing to use an additive may secure a clearance or an authorization for such use by demonstrating that the additive is in fact safe for its intended use. The law exempts from this mandatory clearance provision only those articles which meet one or more of the following criteria:

1. Those which are generally recognized by appropriately qualified experts as being safe for their intended use;
2. Those which were sanctioned prior to the enactment of the Amendment under the Federal Food, Drug, and Cosmetic Act, the Meat Inspection Act, or the Poultry Products Inspection Act; however, such exemptions are limited to the specific uses for which the sanctions were given; and
3. Pesticide chemicals when used in conformance with the Pesticide Section of the Federal Food, Drug, and Cosmetic Act.

Where a substance is not exempt, authorization for use can be secured only through filing a petition seeking that an order be issued pursuant to the provisions of the Amendment permitting the use. The petition must establish that the intended use will be a safe one. If an order issues, the additive may be used only in conformance with the specified terms of the order.

The law was clearly intended to apply to substances that might be in food by virtue of their having migrated from packaging materials as well as those that are added directly. Since a tentative list of direct additives which might be exempt from the clearance provisions of the Amendment has been published, we have been asked many times whether we plan to issue a list of packaging components which are generally recognized as safe for migration to food or that have been approved for such use, thus enjoying an exemption. Our Washington office says we do not have any immediate plans for issuing such a list, but have not definitely concluded that one should not be prepared.

In determining whether or not a packaging material is subject to the Amendment, it is first necessary to determine whether or not under the intended conditions of use, or under any uses which might reasonably be anticipated, any substance may be expected to migrate from the packaging material to food which it contacts. Where studies show that migration may not reasonably be expected, then the substance is not subject to the clearance provisions of the Amendment, except in those unusual circumstances where the packaging material might in some way affect the characteristics of the food. This would not include the customary purposes served by packaging materials, such as protection from moisture loss and preservation of size and shape.

Certain testing procedures are helpful in determining the likelihood of migration from a packaging material under the conditions of use.

Where migration does occur, then of course a determination as to the application of the Food Additives Amendment must be made. The first problem is to determine the identity of the migrant, if possible. If it is not a substance which is exempt for one of the reasons I have outlined so briefly, then its safety for the intended use must be established. This will inevitably involve the filing of a petition.

What should the petition include?

The procedures are set forth clearly in Section 409 (b) of the Amendment itself and in Section 121.51 of the regulations. These were published in the Federal Register on March 28, 1959. Many worth-while comments submitted by interested persons were considered before publication of the regulations in final form.

There are five basic points to be covered in any petition:

1. It should have all pertinent chemical information that is available regarding the additive, i.e., its chemical identity, or, if the identity cannot be determined, the reasons why.

Where the additive is a migrant from food packaging, the petition should tell whether it is one of the original components, a degradation, or a reaction product.

It should explain the process under which the packaging material was produced and the identity and function of all the ingredients.

It should also tell which of the ingredients is responsible for the migratory substance.

All of this is necessary in order that FDA chemists can properly evaluate the identity of the additive and the absence of any other component or degradation product from the formulation.

2. The petition should show the extent to which the additive may be expected to migrate to food under the different intended or reasonably anticipated conditions of use.

3. The petition must contain data showing that the food additive will accomplish its intended physical or technical effect. In most, if not all cases, the indirect additive will have no intended or technical effect in the food to which it migrates. However, it will have been added to the packaging material for a purpose. One of the conditions which the Commissioner of Food and Drugs must observe in permitting an additive to food where a tolerance is required to assure safety of use, is to assure himself from data submitted that the additive does in fact accomplish its intended physical or technical effect. In the case of packaging components, it is our view that the law requires that a migratory substance shall not be permitted in food unless it, or in the case it is not one of the original components, the one from which it is derived, accomplishes the intended physical or technical effect in the basic formulation.

4. The petition should include a practicable method for determining the amount of the food additive in the finished food. This should be a method that can be used with reliable results by properly trained and equipped chemists.

5. The petition must set forth *all* the scientific studies made to determine the safety of the substance in food. To permit proper evaluation, this should include the details of unfavorable as well as favorable studies. If Dr. Lehman were here he could discuss the phase with you in greater detail.

Let me make it clear that no one should rely solely on my remarks in considering whether a petition is complete. The regulations and the Amendment itself are the best guides, and your reliance should be on these documents.

There is no need to take your time to go into detail about what the Food and Drug Administration does once a petition is submitted. Briefly, the petition is reviewed for completeness and obvious omissions. If obvious deficiencies are noted the petitioner is advised and the petition is not filed at that time. When preliminary review shows petition to be complete, petition is filed and petitioner is notified. Decision is made within 15 days.

Within 30 days, FDA is obligated to publish in general terms in the Federal Register, the nature of the regulation or order sought in the petition. (Name of petitioner, name of the additive, the technical effect sought, the quantity of the additive to be present, and the foods or classes of foods involved.) Publication of this notice is simply public notice that a petition has been filed and is not to be construed as authorization to use the additive.

After the petition has been filed, the Administration has 90 days in which to consider it and issue an order setting forth the conditions under which the additive may be used, if at all. When necessary, the Commissioner can extend the time for an additional 90 days, making a total of 180 days.

There are provisions in the regulations for further exchange of information while the petition is under consideration, but I will not take your time to go into detail.

When the Food and Drug Administration has completed its study of the petition, and assuming that no decision to withdraw has been made by the petitioner, the Commissioner must then issue and publish an order in the Federal Register setting forth precisely the conditions under which the additive may be used, if at all. The order may or may not be in accord with the regulation proposed by the petitioner. It may be a completely negative order denying the use of the additive under any circumstance; it may be in complete accord with the regulation sought in the petition; or, it may be somewhere in between, depending upon the evaluation of the facts submitted.

The Amendment itself imposes certain restrictions on the Commissioner with respect to the conditions under which he may issue an order.

1. He cannot issue an order permitting the use of an additive which is shown to produce cancer when ingested by man or animal, or through tests which are appropriate for the evaluation of the safety of food additives, even though it can be clearly demonstrated that the quantity requested in the petition is without hazard or adverse pharmacological effect. No additive may be permitted, even though safe, if its use causes deception of the consumer or renders food adulterated or misbranded under other provisions of the Federal Food, Drug, or Cosmetic Act.

2. If the additive is one for which a tolerance to assure safety of use is required, then the Commissioner may not permit it unless the data before him establishes that it does in fact accomplish its intended physical or other technical effect. Moreover, the Commissioner may not permit an excess of that necessary to accomplish the intended physical or other technical effect, even though the greater amount may be safe. In the light of these latter restrictions, you can appreciate the need for submitting as part of the petition quantitative data relative to the additive and evidence that it does in fact accomplish its intended physical or other technical effect.

3. Now, what sort of order will be issued permitting a food additive which is a migrant from packaging material? Once an order is issued, any person may use the additive in question providing such use conforms with the terms of the order; therefore, the order must be specific and fully informative. To assure a use that is safe and consistent with the conditions of approval, prospective users need to know (a) the identity of the additive, (b) the quantity that may be used safely, and (c) the purpose for which it has been approved.

When dealing with packaging materials, the Commissioner is obligated to publish in the Federal Register the identity of the migratory substance to the extent to which it can be determined whether or not it is one of the original components of the wrapping material. When it is one of the original components, we believe the published order should give: (1) the name of the substance, (2) the maximum quantity that may be permitted as a migrant to food, and (3) the physical or other technical effect it accomplishes in the wrapping material.

Where it is not one of the original components but rather a reduction or a reaction product, then the published order should include: (1) the name of the substance, (2) the maximum quantity that may be permitted as a migrant to food, and (3) the identity of the original component responsible for the migratory material, and the physical or other technical effect that it accomplishes in the packaging material. This, as you will note, does not contemplate publication of the complete formulation of the packaging material, the identity of nonmigratory substances, or of those which may migrate but for one reason or another are exempt from the clearance provisions of the Amendment. Neither would it require publication of the process through which the various components of the packaging material are combined.

An order authorizing the use of an additive becomes effective upon publication in the Federal Register

There are provisions in the Amendment for filing objections by persons adversely affected by an order.

The Food and Drug Administration shall be very glad to continue the past practice of meeting and corresponding with industry scientists, and other representatives, in order that they may secure our views informally on the adequacy of scientific studies to determine the safety of food additives, and other pertinent points necessary to prepare a petition. All such contacts and inquiries should be made with our Washington headquarters for some time to come because our field district personnel are not in a position to be of as much help in this respect during the early period of working under the Amendment.

The "prohibited use" sections of the Amendment became effective last March with respect to food additives used commercially for the first time subsequent to Jan. 1, 1958. Such additives may not be used in food unless they are entitled to one of the exemptions or are authorized for use by an order. As you know, there have been no formal approval of packaging material, at least as of March 3, 1959, although one petition was under consideration at that time.

More specific discussion about data required for evaluation of food packaging under the Food Additives Amendment is incorporated in a paper by Mr. Ramsey of the Division of Food, Food and Drug Administration, Washington, D. C. Mimeographed copies are available on request. The Amendment places the responsibility for developing adequate testing procedures on the petitioner seeking approval of his food packaging materials, but we in FDA stand ready and willing to duscuss any phase of the problem on which we can be helpful.

I hope this compilation of information is useful to you. If you have any questions or problems you would like to have answered I suggest that you use this discussion for guidance in presenting your problem, and address your question to: Food and Drug Administration, Washington 25, D. C.

You are also invited to write to the office of the Deputy Commissioner at any time and ask for the latest information on food additives.

Presented at the meeting of the Delaware Valley Section of TAPPI held in Wilmington, Del., May 22, 1959.

Question: Does this law apply to imported materials?
Answer: Yes.
Question: What are the additives that produce cancer?
Answer: The Food and Drug Administration has not attempted to compile a list of substances that can produce cancer.
Question: Is there information on materials that migrate from paper and paper board?
Answer: Dr. Arnold J. Lehman, Mr. Ramsey, and others have contributed to the literature and a compilation of articles has been published by the Quarterly Bulletin of the Association of Food and Drug Officials of the United States. Copies can be purchased from Joe F. Lakey, Secretary-Treasurer, c/o Bureau of Foods and Drugs, Texas State Department of Health, Austin, Tex.
Question: How would one get data on abrasion?
Answer: This would vary with the substance to be tested and its intended condition of use. I suggest that if you have questions on testing procedures you present the details of your problem to the Division of Food, Food and Drug Administration, Washington 25, D. C. They will be glad to discuss this with you.
Question: Will there be a list made of materials that induce cancer?
Answer: It is unlikely that the Food and Drug Administration will attempt to publish such a list.
Question: Who is responsible for cancer inducing materials being added to a product?
Answer: I do not understand the question. Any one who sells a food additive, or a food containing one bears responsibility to comply with the law.
Question: Will all materials be considered cancer inducing until proved innocent?
Answer: Many are now recognized as "innocent."
Any substance subject to the Amendment will have to be shown to be safe for its intended use. The type of evidence normally developed during acute, subacute, and chronic toxicity studies will serve as a guide in determining whether additional testing possible cancer producing potential is necessary.
In closing, you are invited to request the latest information on food additives from the Deputy Commissioner's office, Food and Drug Administration, Washington 25, D. C.

Empire State

The annual spring meeting of the Empire State Section was held at Whiteface Inn, Lake Placid, N. Y., on June 11–13, 1959. More than 300 members and wives were in attendance, establishing a new record.

The technical program was highlighted by Friday's sessions on paper mill cleanliness, and Saturday's sessions on films and foils. Gordon Rabeler, International Paper Co., Glens Falls, N. Y., served as chairman of the Friday sessions, and G. L. Booth, Dilts Machine Division, Black-Clawson Co., Fulton, N. Y., was the Saturday chairman. Features of the program were the workshop sessions held each afternoon, following the presentation of the papers in the morning. Speakers were able to sit down in discussion groups and informally answer questions.

C. P. Kirchen, D. Lundgren, R. Russell, A. Oetken, J. Dieztel, J. Hanchette and D. H. Hall

John J. Lynch, Corn Products Refining Co., served as toastmaster at the dinners and banquet. The General Social Events Committee was headed by Mr. and Mrs. George Martin, F. C. Huyck & Sons; Mr. and Mrs. James Parmele, St. Regis Paper Co.; and Mr. and Mrs. I. S. DeCalesta, Clinton Corn Processing Co.

Chairman's table at the dinner of the Empire State Section

The technical Program Committee was headed by F. W. O'Neil, New York State College of Forestry; with E. F. Hudson, Lowe Paper Co., as workshop superintendent; J. J. Forsythe, International Paper Co., in charge of junior awards. They were assisted by Grant Cole, Finch Pruyn Co.; W. R. Willets, Titanium Pigment Co.; A. Oetken, International Paper Co.; E. F. Andrews, International Paper Co.; L. Ward, Huyck Felt Co.; J. V. Wolff, Nopco Chemical Co.; and R. P. Sullivan, Monsanto Chemical Co.

The banquets were highlighted by the presentation of a TAPPI Certificate of Appreciation to J. Wayne Morrow, retiring Empire State chairman, by J. W. Field of the Association's staff, and the installation of F. W. O'Neil as new Empire State chairman, by retiring Chairman Morrow.

The Junior Award prize was won by Charles H. Mayhood, Jr., St. Regis Paper Co., Carthage, N. Y., for his presentation of a paper entitled "A Study of the Chemical Balance of Flotation Savealls."

Mechanism of Growth of Bacteria and Fungi

Donald C. Lundgren

MAN's battle to control both the destructive and constructive powers of the microbe has been going on since time began. Reference can readily be made to the Old Testament where numerous inferences are made as regards the actions of microorganisms. As it was in ancient times, for many individuals today the nature of the microbe is shadowed by ignorance. This ignorance has and still is causing frustration and major concern to the people of industry. To many, the microbe may be compared to the Russians, in the words of W. Churchill, "They appear to be a puzzle within a mystery, within an enigma."

Uncontrolled growth of bacteria, fungi, and other types of microorganisms is responsible for numerous industrial problems including slime development, which may eventually lead annually to large financial losses. Today, it is becoming much easier to convince management of this fact, but we still have those "chiefs" who continue to tell their "indians" *not to confuse them with facts, for their minds are made up.*

DONALD C. LUNDGREN, Dept. of Bacteriology & Botany, Syracuse University, Syracuse, N. Y.

Left to right—F. R. Lehman, Ralph Kumler, Paul Wolper, K. C. Taylor, Cliff Morse, H. A. Arbit and G. L. Booth

Jim Field presenting certificate of award to Wayne Morrow

Facts, pertinent to the growth of bacteria and fungi, when applied to biological problems can help combat the troubles of industry including those of the paper industry. Wherever biological problems arise in an industrial operation, be they slime formation, product deterioration, organic spoilage, etc., the problem has its genesis with *growth* of the biological agent.

I have been asked to discuss the mechanism of growth of bacteria and fungi. This term "mechanism" to a biologist is extremely motivating and is usually enough to put him on "automatic pilot" wherein he can ramble for hours. To a heterogeneous audience such as this, this can be very unpleasant. Thus, I shall attempt a qualitative, nonmathematical expression of the mechanism of growth, emphasizing wherever possible the practical consideration of this response as it might apply to slime and paper manufacture.

In most instances, growth in general will be considered without particular reference to any category of microorganism, for in many aspects of growth both the fungi and bacteria behave similarly. I must make one assumption. That is, that we are all somewhat familiar with bacteria and fungi insofar as their morphology and/or structure is concerned, and that we recognize the presence of nuclei, nucleoli, cytoplasm, germplasm, chromosomes, chondriosomes, cell walls, semipermeable membrane, and vacuoles.

Before we discuss the growth of bacteria or fungi, let's briefly establish a necessary biochemical perspective. A living cell must comprise an *organized* system. A single fungus cell or a bacterium can carry on more reactions in the space of a few microns than a mill operation can in a huge paper company. And it seems that each day more and more new reactions are discovered in these single cell entities. Chemical reactions going on simultaneously include: oxidation, reduction, synthesis, degradation, hydrolysis, alkylation, esterification, and transamination to name only a few. The beauty of this chemical picture is in the balance and harmony of the many chemical transactions. Most of these chemical reactions are aimed at supporting growth. All living organisms must grow. Growth by microorganisms necessitates the intake of water, organic and inorganic foodstuffs, and the synthesis and movement of new organic substances. The substances that organisms use for growth are called metabolites and nutrilites. Many microbes are capable of synthesizing for themselves most of the metabolites that they need. Those metabolites that the cell cannot manufacture must be available in the exogenous environment or the organism dies. Wide variations are found among fungi and bacteria as regards the different metabolites they can synthesize. Often one microorganism can manufacture a metabolite needed for growth by a neighbor. Such a process of reciprocity often aids in the establishment of microbial societies consisting of different groups or organisms which are oftentimes capable of magnifying slime problems.

Since the present paper is referenced to growth of slime producing microorganisms, perhaps it would be expedient at this point to cite some of those organisms established as slime formers in paper mill operations. Also, we should say that given the proper conditions any organism can form slime (or a reasonable facsimile). Bacteria appear to be the most important single group of slime formers. Specific organisms most frequently encountered with paper mill slime include: *Escherichia, Aerobacter, Micrococcus, Pseudomonas, Achromobacter, Flavorbacterium, Alcaligenes,* and *Bacillus.* Fungi may be related to so-called "splatter slime," but are not generally encountered in submerged slime since these organisms do not grow well when submerged in a milieu deficient of oxygen. Filamentous fungi of the mold type such as *Penicillium, Aspergillus, Citromyces, Fusarium, Alternaria,* as well as others, have been demonstrated to be associated with biological slime formation.

Wayne Morrow, past chairman, turning over office to Professor F. O'Neil, next year's chairman

GROWTH

As regards the mechanism of growth of bacteria and fungi, let us approach the problem in this manner. Growth is the ability of a system to reproduce itself and is one of the prime characteristics of living matter. In speaking of growth of microorganisms one must specify between the growth of the individual, that is, the cell, and growth of the culture, that is, the cell population. Consequently, in thinking about microbial growth and its quantitative measurement one must be aware of whether his data are based on cell numbers or on total cell substance. In the former we would have cell concentrations, such as numbers of cells per unit volume, while in the latter we have microbial density, defined as total protoplasm per unit volume. With growth, *time* is an important variable, and the rate of growth is an important characteristic of biological systems. In determining the rate of growth as well as the initiation and duration of growth, *temperature* is also an important variable.

Quantitative Aspects of Microbial Growth

The factors which control microbial growth are closely knit and do not readily lend themselves to subdivision and individual consideration. These factors or phenomena con-

C. H. Mayhood, Jr. award speaker (left), J. J. Forsythe

trolling growth to be discussed include: (1) factors dependent upon the nature of the organism (endogenous factors), (2) factors dependent upon the environment (endogenous factors), and (3) the temperature factor.

The nature of the organism dictates the conditions essential for the initiation and the continuation of bacterial growth (protoplasm synthesis and cell division). Cells grow and divide according to a predetermined design established by its genetic structure. Growth is implemented by the enzymatic equipment of the cell which appears to be under direct control of the genetic material. The particular enzymatic mosaic of a cell is determined by the cell's genetic material with formation and activity of the enzymes being influenced by physical and chemical factors in the environment. Likewise, conditions for the formation of specific cellular constituents such as capsules, as well as metabolic by-products, such as slime, may often be organism-specific and may differ from those conditions optimum for growth. The nature of the organism will also determine the temperature at which the biological reactions will proceed to support growth. Temperatures for growth may range from as high as 70 to a low of 10°C. with the more optimum temperatures being in the neighborhood of 32°C.

The effects of the environment (the medium) on growth must be investigated from both the standpoint of composition and concentration. How complete (in terms of nutrilites and

Workshop discussion on bacteria, slime and foam. Discussion leader in dark suit, Ralph T. Russell

metabolites) a medium is for a particular organism(s) will determine the final amount of growth as well as growth initiation and growth rates. The medium must contain: (1) energy supplying substances such as glucose, starch, etc., to push the synthetic processes; (2) nitrogenous substances, such as amino acids, ammonia, nitrate or nitrites to furnish the building materials for new cell substance (protoplasm); and (3) essential metabolites such as vitamins or growth factors which the cell cannot synthesize; these factors serve principally as catalysts for energy release and synthesis. An adequate understanding of the chemical environment of a culture is essential for any study of microbial growth.

The most important effect of temperature on growth is through its effect upon the rates of chemical reactions. Within the temperature range of biological reactions a ten-degree rise in temperature will about double a chemical reaction. Organisms do have an optimum temperature for growth which is referred to as that temperature at which the organism grows most rapidly.

Growth and Population Cycle of a Microbial Culture

A series of events are initiated when one or a few microbial cells gain access to a medium adequate for growth. These events lead to the increase in a microbial population, or more simply, growth of a culture. The growth of a culture can be

Workshop discussion on the "clean paper mill"

divided into three phases with transitions occurring between each. These phases are:

1. The stationary phase or lag phase; the period initiated immediately upon planting the organisms into a new medium.

2. Exponential phase or logarithmic phase; this phase commences with the transition from a stable population to one of rapid multiplication. During this phase there is a time when all viable cells divide at a rate equivalent to the maximum rate of growth which is characterized by an exponential rate of population increase.

3. Stable population phase; the final phase of a population where the death rate is equivalent to the multiplication rate to give a stable population.

In the population cycle of growth the quantitative expression of biological change can be reduced to a general mathematical description which can be extremely helpful in predicting a culture's response to a given set of conditions. Time does not allow for a consideration of such expressions but mention should be made to the importance of applying *rates of multiplication* and *generation time* (time for a doubling in numbers) to growth studies.

Toxicity and the Chemical Environment

There is a time during culture development when growth does not proceed unchecked. At such a time, either the nutrients for growth are depleted or metabolic by-products inhibit population increases. Natural growth checks such as these are even more pronounced in mixed populations where greater variations in chemical climates occur and are frequently unfavorable for some of the species. The phenomenon of commensalism (amicable growth of different organisms) is common to habitats harboring nondomesticated microorganisms. The inhibition of microbial growth by certain chemical climates has led man to investigate specific and nonspecific toxicity of chemicals on microorganisms. The survival of a microbial population in contact with toxic agents depends upon a number of factors: some of these are: (1) concentration of agent, (2) organism, (3) contact period, (4) pH, (5) temperature, and (6) amount of organic material in the suspending medium. We have already defined a living organism as one that is capable of reproduction, and an organism that resists the association with the toxic agent is still potentially capable of reproduction. Reproduction or growth may not occur while the cells are in contact with the toxic chemical, but may readily proceed when cells are removed from this climate. A compound which acts to prevent growth while it is in contact with microorganisms is referred to as *bacteriostatic* or *fungistatic*, while a chemical which acts permanently in its effect is called *microbicidal*. Such terms as these are often more apparent than real, for microbial reproduction depends primarily on the amount of the agent involved. High concentrations are frequently lethal. The actual range from noninhibitory → inhibitory → lethal is dependent upon each chemical agent. Some chemical agents may even influence an exhibition of growth rather than an inhibition when added at particular levels. Reasons for this *peculiarity* are not known.

The mode of action of a particular chemical on growth may be either specific or nonspecific. In the former, the agent may interfere with a single step in a reaction sequence which is a part of an intricately geared machinery of the living cell, while in the latter the agent would inactivate together a number of different cell processes. The reactive sites in a cell responsible for the toxicological manifestations are the protoplasmic areas of the cell membrane, cytoplasm, and nucleus. The cell membrane offers the initial barrier to the chemical agent. If the agent is unable to penetrate and affect the membrane the compound cannot harm the cell no matter how reactive it is with the cells' internal contents.

Once toxic agents have penetrated the cell's membrane the action may be upon cytoplasmic protein or upon specific metabolic reactions. Interaction with cytoplasmic protein results in inactivation, precipitation or protein coagulation due to the disruption of the colloidal state of the organized cytoplasmic protein. Dehydrating agents and high concentrations of salts react in this manner, as well as mercurials, arsenicals, formaldehyde, anionic detergents, acid dyes, quaternary ammonium compounds, cationic detergents, and basic dyes.

Protein alteration is a drastic means of inhibiting microbial growth—in reference to physiological action. More subtle inhibition is possible by interfering with specific metabolic reactions of the cell concerned with metabolite synthesis. The chemical agents active in this manner are called "antimetabolites." Control of organisms causing disease has been possible with "antimetabolites" and has opened up the new area of selective toxicity. The application of "antimetabolites" has not yet reached the paper mills. However, it is just a question of time until results of present-day basic research make it feasible to employ this type of inhibitor in industry.

For the past 35 min. the dynamic nature of microbial growth has been underscored. Knowledge of those fundamentals responsible for microbial growth makes a rational approach to growth control feasible. Evidence of some accomplishment in microbial growth control in the paper industry is available. However, we have a long way to go before we completely neutralize the problems resulting from uncontrolled growth of both bacteria and fungi.

Presented at the meeting of the Empire State Section of TAPPI held at Lake Placid, N. Y., June 11–13, 1959.

Slime and Odor Control

Ralph T. Russell

The presence of slime in paper mills is practically universal. The problems created by its appearance in mills has serious effects from both the paper quality viewpoint and the individual structural components of the entire system. The purpose of this paper is to briefly relate the nature of the problem, the early remedies for the correction of slime deposits, the development of improved germicides and, in general, to examine the knowledge gained from research in the field of paper mill slime and odor control.

Slime is a heterogeneous mixture of microorganisms, metabolic products of these organisms, and materials, both chemical and nonchemical, used in the usual papermaking processes.

The composition of the slimes is very complex and extremely variable from sample to sample.

The particular microorganisms present may include algae, fungal hyphae, yeast cells, protozoans, and numerous bacterial types. The presence of starch, sand particles, clay, Al_2O_3, $CaSO_4$, and Fe_2O_3, together or in individual combinations, contribute structural elements to slime formation although their proportions may vary with each sample. It is not uncommon to find slimes composed of almost pure microorganisms and the products they synthesize, nor is it an infrequent occurrence to find gelatinous masses almost devoid of microbial growths.

The direct results upon paper manufacturing and the product quality are serious and costly. Slime presence interferes with the proper operation of a papermaking machine. It causes breakages in the sheet, holes and spots in the paper or paperboard, plugs felts and wires, accumulates in stock lines and can even cause corrosion of pipelines and other equipment. Production tonnage is lessened and the over-all quality of the manufactured product is impaired. The very presence of slime makes it almost impossible to maintain optimum conditions for the manufacture of high grades of pulp and paper.

Ralph T. Russell, Associate Director, Microbiological and Biochemical Research Center, Syracuse University Research Corp., Syracuse, N. Y.

Slime formation is responsible, to a large degree, for the introduction of odor problems in the mill and the finished paper product. The seriousness of this effect, particularly upon the paper product, needs no emphasis.

The full import of the nature of slime and its manifold effect was not recognized until recent years. Previously, it was the common opinion that adequate slime control was not economically feasible and that slime growths in mill systems, while an evil, had to be tolerated. It was only when the loss of tonnage increased noticeably that anything in the way of slime control measures was introduced.

First improvements in slime control were secured by the use of chlorine. Heavily chlorinated water was used in wash-ups, in stock dilutions, and at showers. It was also considered good practice to use strongly chlorinated make-up waters, treat white waters, and use the direct application of chlorine to points of slime accretions in order to decrease slime incidence.

The failure of chlorine and chloramine treatment to control all slime led to intensified investigations concerning the dynamics of slime formation and, particularly, the identification of the precise organisms involved. This knowledge formed the basis for the introduction of multiple control treatment wherein two or more chemicals were employed in a mill, each compound specific for the group of microorganisms it affected. The industry was gradually acquiring from its research programs, a growing body of data which furnished a considerable background for understanding the cause, composition, structure, and control of slime formations.

Perhaps the greatest advancement in slime control resulted from the increased demand for paperboard products which seems to have been brought about by World War II. This demand kept mills operating continuously without shutdowns for clean-ups with the result that slime problems were aggravated beyond any effective control measures.

The government also seems to have added incentive, at that time, for studies to develop a treatment for the preservation of paperboard products.

This research, along with the increased slime problems, resulted in the introduction of many new chemicals and improved methods of applications aimed to secure maximum protection against the effects of mill microorganisms on plant equipment and products. Although the practice of slime control measures has become universal, there still exists, in numerous instances, a lack of complete understanding as to the effects of slime growth on the entire papermill system. Visual slime effects that mar the sales appeal of a paper product and lowers production tonnage still provides the greatest impetus for the installation of control measures. However, there are effects less directly observable but which, nevertheless, in their entirety, produce profound and serious effects upon the whole system. The plugging of pipelines, wires, felts, and showers all interfere with maximum efficiency of the papermaking system. Industry has long regarded slime as a general nuisance and treated it more or less accordingly, with as few control measures as possible, expecting miracles of the control agents. Too often, little recognition is given to the complex nature of slime formation and its build up within a system without showing any direct evidence of its presence. Visual evidence of slime should not be the sole criterion for installing or increasing control measures. There no longer exists any basis for a part of the paper industry to consider slime as inevitable and subject only to partial control with half-measures. The problem, in the contrary, must be approached with complete control and administered from a strictly scientific view. Visible evidences of slime today indicates a dirty and inefficiently operated mill system.

The increased demand for paper products in the food packaging industries has attracted the attention of public health officials. They have set up standards affecting production processing and quality control. Stream pollution regulations have caused mills to close their systems in order to comply with these regulations. These interventions have caused the industry to reconsider some practices. The use of outmoded and unrelated practices of slime control is rapidly being replaced by a logical scientific approach to the problem. The paper industry is beginning to recognize the inadequacy of chemical treatment as the only method for the attainment of compliance with the new regulations and standards.

A large share of this important new approach to the slime problem is being carried out by individual chemical concerns and the results are of a high degree of excellence. There is, however, a definite need for continuing research from a disinterested source, embracing the factors involved in the control of slime and odor formation.

The new Food Additives Amendment law passed by Congress in September of 1958 will no doubt be a very strong stimulus to increased research in the field of slime and odor control. The status of all chemicals used as slime control agents in the food wrap mills must be determined. Many of the germicides already in use may fail to meet the requirements imposed by the law and the germicide industry will be forced to develop acceptable chemicals. The practice of sanitation will be more important than ever.

It is beyond the scope of this report to carry out any further discussion of slime control in mills; however, it should be stated that the causes of slime formation and malodors in mills are interrelated. Odor and its development is not totally due to microbial factors, but the influence exerted by their presence is beyond question. Mills have become more diligent in their attempts to reduce slime and odors, and it is unfortunate and somewhat ironical that in some instances the odors of contamination are effectively reduced but are replaced by the odors of chemicals used for sanitation. Cleanliness then, is also a very important factor in the control of odor. The application of toxicant chemicals in a dirty system as a substitute for periodic clean-ups leaves much to be desired and, as already stated, such a practice is a serious deterrent to odor control.

If cleanliness is a major consideration in slime or odor control, then why is it necessary to use any other aid? The answer has become apparent as a result of mill studies. Briefly stated, it is impossible, within practical limits, to effectively eliminate either slimes within the mills or odors in the finished product by cleanliness alone.

The observations made during the past several years have shown that all but a small percentage of paperboard manufactured by the paperboard industry was found acceptable for consumer use. Of this small percentage failing to meet consumer requirements, part was board manufactured for food packaging and necessarily faced rigid standards governing odor and taste transfer. This board, when evaluated in the laboratory by any of several techniques, yielded easily discernable odor differences where were highly characteristic. One of the odors that appeared most often and always seemed to be associated with the use of waste furnishes was an odor described by the industry as "paperboard." The following is a list of the general types of odor which have evolved from our various odor studies and their effect on taste transfer:

1. *Sweet, pleasant, and/or neutral.* These odors were not considered objectionable and generally did not impart an off-flavor to food packaged in the board.

2. *Paperboard.* This odor is one of the most common in the industry, and is most frequently associated with board made from waste furnishes. This odor, at one time, was responsible for 90% of all complaints of off-flavors in foods packaged in board made from semiwaste furnishes. The incidence of this odor has decreased considerably within the past few years.

3. *Sour or acid.* This is a medium level odor which when inhaled gives the observer a clear reminiscence of soured milk products.

4. *Musty or newsy.* This type of odor is definitely objectionable and reminds the observer of the odor of freshly plowed earth and damp cellars.

5. *Foul or putrid.* This odor is often associated with stagnant pools and bacterial rotting.

6. *Chemical and/or medicinal.* This group includes odors reminiscent of laboratories and hospitals. The odors caused by misuse of germicides and other chemicals, inks, etc., may fall into this class.

One of the most common malodors that occurred in odor complaint samples was the "paperboard" odor. This odor varied in intensity from sample to sample; from a high intensity yielding definite taste transmission to low intensities which might or might not transfer as malflavors. The odor also developed during shelf life in what are apparently odor-free boards. Although the odor occurred most frequently in paperboard made from waste furnish, it was also found occasionally in other types of paperboard.

We belived that the odor could be eliminated or reduced to a point where it was no longer objectionable, if we knew the basic causes for the odor. Therefore we decided to carry out a series of investigations directed toward finding the factors responsible for this one particular objectionable odor.

Our research was organized to determine the following:

1. The nature of the chemical or chemicals responsible for the odor.

2. A suitable and reasonably inexpensive method to reduce or eliminate the odor during commercial paperboard manufacture.

3. An instrumental test for measuring levels of the odor in finished board samples. This test was to be used as a quality control measure.

4. An instrumental test for determining the *potential* paperboard odor, i.e., how much of the odor, if any, would form during shelf life.

We feel that we have successfully achieved all of these objectives.

The odorous substance can be isolated by steam distillation of a paperboard slurry (10% consistency). It is of an organic nature and indications are that the odorous substance is an organic sulphur compound which also contains a ketone group. The exact structure of the substance has not been determined absolutely.

The odor formation can be eliminated during the board manufacture by a simple oxidation treatment. Oxidizing agents such as sodium or calcium hypochlorite, a combination of chlorine and sodium hydroxide, can be added to the filler or backliner stocks to eliminate the odor. The dosage of the oxidizing agent varies between 0.1 and 0.4% based on the dry weight of the board and has given excellent results. Not only odor control is achieved but also more effective slime control can be obtained. Reducible sulphur compounds, frequently causing tarnishing can also be considerably reduced by this oxidation treatment.

A quantitative microtest for the amount of odor sulphur present in a steam distillate of the paperboard slurry was developed and the results correlated with actual odor tests performed by an organoleptic panel. It was found that the amount of odor sulphur present in a steam distillate is approximately proportional to the intensity of odor exhibited by a dry paperboard sample. This test is now used routinely in the laboratory as an analytical measure and serves as an aid in our odor tests.

Various fibrous raw materials were subjected to analysis to determine the importance of each in the formation of "paperboard odor." Only groundwood and soda pulp failed to exhibit the odor. This type of information is important in setting up an odor control program within the mill since the majority of sulphur compounds are introduced through the secondary stock. In order to avoid immediate or eventual odor formation, relatively sulphur-free furnishes should be used.

The formation of paperboard odor during shelf-life results when a source of reducible sulphur reacts with a wood component (a neutral carbonyl compound).

The addition of alum or other sulphate containing compounds to the stock system will not increase odors unless sulphur reducing organisms are present which reduce the sulphate to hydrogen sulphide.

It is interesting to note that complaint samples having the typical paperboard odor have decreased sharply over the past few years as mill sanitation and better slime control measures have been initiated.

In the work just discussed, we not only learned about paperboard odor, its causes and control, but also about tarnishing and how to produce an antitarnishible paper or board. An improved colorimetric method for the determination of reducible sulphur was developed and published (*Tappi* 39: 628 (Sept. 1956)).

Studies have already been initiated to determine the factors responsible for other odors included in the list. It is expected that in the near future we can furnish the mills with a definite plan for the control of the "musty" or "mildewy" odors.

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Effective Microorganism Control Program

J. J. Dietzel and C. P. Kirchen

As THE name implies, microorganisms are minute forms of life. However, their small size is in no way indicative of the impact that they have on our lives, even if we disregard those that cause human disease. We find them everywhere: in the soil; in the air we breathe; in our food; on and in our bodies. They may kill the plants and animals we raise for food, spoil food products after they are harvested, and deteriorate the clothes we wear. They decay the wood from which we build our houses and spoil, disfigure, and shorten the life of the paint used to decorate them. In paper and pulp mill systems, they manifest their presence by forming gelatinous masses, which break loose and cause spots and holes in the sheet, breaks in the sheet, plug felts and screening equipment, and a number of other problems, reducing the efficiency of the mill operations and quality of the finished product. Also, when uncontrolled, they cause variations in the viscosity and adhesive characteristics of coating colors, resulting in unevenly coated paper and generally poor quality.

Despite the destruction which they cause, microorganisms also have an essential role in nature, and other constructive uses are made of them in the production of antibiotics, beverages, dairy products, chemicals, and in sewage disposal. Plant and animal life could not survive long without them. When leaves and other portions of trees and plants fall upon the soil or when an animal is buried in the upper portions of the soil, a number of microorganisms work together to decompose this material. Thus, microorganisms return essential materials to the soil by disintegrating what would otherwise be insurmountable quantities of waste and dead bodies that would accumulate with amazing rapidity.

Both the Dr. Jeckyll and Mr. Hyde roles of microorganisms in our life command our respect. Even if we were willing to undertake the staggering task of eliminating microorganisms from the earth, the course would be unsound. We must learn to live with them, regulating their activities, to retain the good and minimize the bad.

There are several factors that influence growth of microorganisms. They are food supply, moisture, temperature, air tension, inoculation, chemical environment, and pH. Bacteria and fungi do not have chlorophyll and thus are

J. J. DIETZEL and C. P. KIRCHEN, Buckman Laboratories, Inc., Memphis, Tenn.

unable to utilize energy directly from the sunlight as do the higher forms of plant life. Thus, the energy necessary for their maintenance and growth must be obtained in other ways. Some bacteria obtain their energy from the oxidation of inorganic compounds and obtain the carbon they need from carbon dioxide. The iron bacteria are typical of this group. Also, sulphur bacteria obtain their energy by reducing sulphates, sulphites and sulphur itself to hydrogen sulphide, using the oxygen liberated in the process to oxidize organic carbon compounds. Other bacteria obtain their energy requirements from the common carbohydrates and protein materials used in paper and pulp mills, such as cellulose, wood sugars, starch, gums, glue, or casein. Thus we see that the pulp and paper mill provides an abundant supply of nutrients.

All microorganisms require high concentrations of moisture. While they may have their individual requirements, most of these are readily supplied by the papermaking operation. Most slime-forming microorganisms found in pulp and paper mill systems have an optimum temperature range between 70 and 150°F. Probably the optimum pH for most rapid growth is around pH 7, although there are many that will grow very well at a pH as high as 9.5. Nutrition or food supply in general is no problem, because most pulp and paper mill systems, have adequate amounts of carbohydrates, in the form of starches, gums, or the actual cellulose of the fibers. Proteins in the form of glue or casein provide even better food, because these break down into amino acids. Inoculation of the systems may come from the mill water supply, inadequately preserved lap stock, moist groundwood pulp, or other contaminated fiber supplies. Wastepaper furnish is one of the greatest sources of contamination.

Fresh water entering a mill should be carefully examined and treated to prevent contamination. Until recently, many mills throughout the country ran with fresh water taken from a nearby river, without microbiological treatment. These mills usually had rather severe slime problems and often had scale problems on the paper machine and pulp mill. Similarly, dirty paper or low brightness paper often resulted from the color in the water.

To control slime-forming microorganisms it is highly important to choose toxicants which provide a wide spectrum of activity. The microorganisms which cause disease in man or animals are called "pathogens." Fortunately, practically all water-borne microorganisms that are pathogenic to man are easily controlled by chlorine. However, it is of interest that, although chlorine (as used for treatment of fresh water) will control pathogens, there are many other organisms (including a number of the slime formers) which are not controlled by chlorine in the normal levels at which it is applied to water in a mill.

Similarly, there are microorganisms which show unusual resistance to strong chemical toxicants; for example, phenylmercuric acetate. The mold *Penicillium roqueforti* showed up in studies in Sweden some years ago, on the preservation of moist groundwood pulp. This mold seemed to thrive in the pulp in spite of high levels of this toxicant.

The next consideration is the degree of control desirable for maximum efficiency of operation. Experience has shown that the best results are obtained, for the least amount of expenditure, when we treat to control the growth of microorganisms in the system. It is not necessary nor economically sound to kill off all the microflora in the system. When we preserve the microbiological balance in the system with properly designed toxicant mixture, effective control of the microflora exists at a lower cost level. This is in preference to a selective reduction of a portion of the microflora, by a toxicant which is either primarily a bactericide or fungicide alone.

A properly designed microorganism control program should be tailored for each particular mill, and even, for each particular machine system. The first consideration should be an estimate of the losses caused directly and indirectly, by the growth of microorganisms. This is obtained by analyzing production and operating data from one machine at a time so as to make a careful survey of the operation and determine the magnitude of the losses which slime may cause if not controlled. For example, in addition to wet end breaks, wrapped driers, and plugged calender stacks (all of which mean loss of production time on the machine), many times the sheet may not break but continues on through the machine. Thus, defects may be missed by inspection and go out in the finished paper to the customer. The resulting loss of acceptance of the product in a highly competitive market represents a substantial but intangible loss. I believe that everyone here today, will admit that at no time has quality been so critical as now. Many mills have taken the stand that they cannot afford slime, and have taken steps to set up sound slime control programs, with expenditures for slime control chemicals to the point of diminishing returns. Years ago when mills ran wide open systems and spilled large quantities of fiber, filler, chemicals, and heat to the sewer, few had any real slime problems. However, these losses soon became a factor in the over-all economy of mill operation, and steps were taken to increase the closure of systems to reduce these losses to a minimum. Increased steam consumption due to bacterial plugging of felts, also called attention to proper control methods.

Final aspects of the effective microorganism control program should include adequate preservation of clay slips and coating colors. Some mill operators still adhere to the principle that as long as they can't smell any off-odors in the coating, the coating is satisfactory to use. Enzymes produced by bacteria will cause a drop in viscosity and adhesive quality in a relatively short time, without any evidence of odor. In a careful study with one of the large southern mills which does high-speed, on-machine coating, we made checks of the coating colors with their research group, utilizing a much more sensitive viscosity measuring device than they had previously employed. This was done over a period of 30 to 60 days. A number of times we found major viscosity changes in the coating color which correlated with difficulties on the coating unit at the paper machine. The previous viscosity measurement had not shown these changes, and the pH changes had been so slight that they had been considered a normal variation of the process. We then set up a program and adequately preserved the coating color for this particular large machine and ran the machine for 60 days. The results were very striking. Coating operations on the machine ran much more smoothly, and the net tons of salable coated paper, produced in reels, increased. The reduction in complaints from the magazine publisher who consumed all of the output of the machine confirmed that the expenditure for adequate preservation of the coating color was more than compensated for by the increased profits from the greater production and the intangible value of improved customer good will.

The total loss which may be caused by uncontrolled growth of microorganisms throughout the pulp and paper mill systems may be as high as $1 to $5 per ton. In planning the treatment program, it is sound to provide some safety factor to insure that the savings from slime control will be achieved on a continuous basis. A safety factor is as logical in microorganism control as it is in sound engineering practice.

One of the first spots where slime-forming microorganisms and their brethren, the cellulolytic microorganisms, cause trouble is the pulp mill. The cellulolytic microorganisms are those which may not necessarily form slime but which, when left in contact with cellulose, will cause degradation of the cellulose. In plain, papermaking language, they may cause loss in yield and loss in strength in pulps. More and more is being learned about this as more pulp is being stored in high-density storage chests throughout the industry. For years these organisms worked when pulps were stored in wet laps. Many mills sprayed preservatives on the surface of the wet lap to control mold growth, but nothing much was done about internal degradation because wet lap furnishes were graded

and additional long-fibered stock put in to bring up strength, if necessary. Yields, unfortunately, were never measured carefully; in fact, to this day there are many mills which still have no accurate measure of their over-all yield from tons of moisture-free wood to tons of salable paper. I can assure you that a lot of effort is being directed at this problem and that more accurate yield information will be forthcoming soon. In the pulp mill, generally speaking, groundwood pulp provides the most favorable medium for the growth of the microorganisms. Unbleached sulphite pulp and unbleached, semichemical, hardwood neutral sulphite pulps are similar to groundwood pulp in this characteristic. Straight alkaline cooked pulps, such as soda pulp or sulphate pulp, generally are not so good a medium for rapid growth of these microorganisms as the aforementioned ones. The result is that we find treatment programs operating in most groundwood and sulphite mills and in many semichemical, neutral sulphite mills but in few soda pulp or kraft pulp mills.

Moving on through, we come to the paper mill. In a number of mills, there may not be beaters or pulpers used for all stock preparation. In some instances, at least a portion of the furnish is slushed right through from the pulp mill. Thus, the trend in the industry is toward feeding the slime-control toxicants by means of chemical-proportioning pumps into points in the system other than the beaters or the pulpers. The use of these reliable chemical-feeding pumps, together with automatic timing devices which may start them or shut them off automatically, enables the mill to realize more efficient treatment. A few mills are fortunate to have outstanding crews in their heater rooms where reliable addition of the slime-control toxicants to the proper beater or pulper goes on every shift. However, we do think that the trend toward the use of these proportioning pumps and the introduction of the slime-control toxicants (into either the white water or the stock at selected points in the system) is a part of the over-all program of moving toward more uniform operations in the mill.

We cannot overemphasize the importance of good housekeeping in pulp and paper mills. Daily treatment with effective toxicants for control of slime-forming microorganisms is really just a part of good housekeeping by the crews in the pulp or paper mill. Effective use of high-pressure water hoses from pumps such as the "hydrosilica" type and others, properly applied with special fittings to get into various parts of the systems, all comprise good housekeeping. Training of crews for good housekeeping comes only with lots of experience.

With outstanding slime control, wash-ups are easier. No troublesome slime accumulates on the walls of the headbox, in chests, on trays, or in other areas. Thus, a good and fast wash-up can be conducted. Generally, where modern paper machines are operated with effective slime control, the wash-up takes no more than the time necessary for the clothing change. Spray treatment with an effective spray toxicant is very useful in mills where there are wooden areas, rough concrete, or rusted iron or steel. Spray treatment is widely used in the industry; however, as machine systems are rebuilt and with the trend toward stainless steel, tile lining, etc., less spraying is done now than was done some years ago. Similarly, the industry is spending more money and doing a more effective job for over-all slime control in treatment during operation and not relying as heavily on spray treatment during shutdowns. When we checked into this further, we learned (among other things) that "down time" is becoming so valuable on machines that mills can't afford to shut them down long and conduct the spray treatments as they did some years ago. In connection with clean-ups, periodic boilouts which can be scheduled to coincide with holiday shutdowns are invaluable. This enables the hot detergent-toxicant mixture to get all through the stock lines and the white water lines and clean these out to the same degree that the visible areas of the paper machine system are cleaned out on regular clothing changes. Generally, we find now that most mills are conducting their boilouts on a quarterly basis, conducting them before they shut down for a scheduled holiday. They utilize the heat of the system and add the caustic soda and toxicant right into the white water, shut the stock off, and then recycle the hot detergent-toxicant solution for several hours.

In summary, effective microorganism control results from a recognition of all the factors which influence microbiological growth. We know that they are mainly, inoculation, temperature, pH, nutrition, and these determine the slime potential of a given system.

The use of highly effective toxicants is only part of the general good housekeeping and sound engineering required to provide outstanding slime control. Through mechanical cleaning is the other essential.

The proper understanding of the individual role of each, will afford the maximum benefit from the slime control program.

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Foam Control in the Paper Mill

D. H. Hall

FOAM is certainly familiar to all of us from one standpoint or another, but it is surprising how little is definitely known about its nature and behavior. Theories developed for various research systems have, over the years, been boiled together to develop what are generally accepted current thoughts, but foam certainly still seems a good bit away from being tied down as a science. We keep trying to move foam control further from the realm of magic, however, and we would hope that the few thoughts we have assembled may give someone an idea that will help in that direction.

WHAT IS FOAM?

Foam is most widely thought of today as more than the visible froth apparent in many points of our paper mill systems, or as the lather, foam, bubbles, or head associated with many other items in our everyday life. In considering the need for foam control in the mill, we must consider foam to be all the entrained air in the system, whether visible as surface bubbles, or present as loosely or intimately entrained air bubbles in the stock. Various problems in mill operation certainly can be associated with each occurrence.

Foam is described formally as the dispersion of a gas (usually air) in a liquid, comprising interconnecting films enclosing the entrained gas. Bubbles vary in size from a micron to "loose foam" bubbles 100 or so microns in diameter; their formation being influenced by many properties of the liquid and of the surface where the foam is forming. These properties would include surface and interfacial tension, surface viscosity, temperature, solubility, pH, etc. Surface tension has often been considered the main factor, but has come to be thought of more as a main factor as it has been pointed out that foam formed where surface tension has been lowered will be short lived indeed unless other components in the system act to stabilize it.

WHAT CAUSES PAPER MILL FOAM?

For foam to occur, surface tension must be lowered to allow initial formation, and the system must contain components having, for instance, sufficiently high surface viscosity that the foam will be stabilized.

D. H. HALL, Nopco Chemical Co., Newark, N. J.

In paper mill stock systems, entrained air is present as a result of turbulence and cascading in the process, excessive amounts of water soluble components in the furnish, residual pulping or bleaching liquors in the stock, and sometimes of incomplete wetting of the fibers. Foam problems have been associated with high proportions of size, dyes and fillers, oxidized starches, protein from wastepaper, excessive alkalinity of stock or incomplete precipitation of rosin size, and not infrequently to leaky pump packings in stock transfer lines.

As a potential foam producing system, the paper mill is probably more complex than any other manufacturing operation. By way of comparison, the nature and quality of the beets pretty much determines foaming characteristics in the beet sugar industry, while the paper mill, far from being dependent on wood alone for its foam problems, must consider properties of additives, process water, and mill equipment itself as contributors to, if not actually causes of, foam in meeting its entrained air problems.

FOAM PROBLEMS IN THE MILL

In considering some of the unpleasantness that can be traced to foam in the papermaking operation, suppose we think first of the possibilities for down-graded or reject paper and board, and see whether we can suggest causes.

In addition to actual broke from drier section breaks; spotted and dirty paper, paper or board where basis weight and general uniformity is below specifications can often be traced to inadequate foam control. Froth spots in the paper are caused by bubbles carrying fiber, size, or color on their surface. When they break, light spots in the sheet—or dirty blemishes on the surface of the paper generally result. In heavily filled sheets, the foam spots may hold excesses of the filler or dye, making a dark spot when the bubble is broken. In extreme cases, a large foam and fiber slug can pass all the way through the driers without causing any break and is often likely to be blamed on slime.

If we use deinked stock, graying can result if froth remains with the stock during washing in the wastepaper plant as the foam has an affinity for carbon particles which thus would be deposited onto the washed pulp and carried to the papermaking operation.

Nonuniformities in basis weight and formation are understood when we consider the variation in stock density that would exist where varying amounts of air are associated with the fibers.

If a size press is employed, turbulence, the fact that, particularly in the case of porous papers, size is apt to replace the air in the sheet, the size in the tub absorbing the air, and the inherent tendency for starch and gum slurries to foam would point to a need for foam control separate from the machine system proper. Here quality problems in the event of streaking, or the housekeeping problem of foam overflow would be the more obvious indications of the foam condition.

The effects of uncontrolled foam will probably be most evident between the paper machine press sections and stock preparation, whether a fourdrinier or cylinder machine is involved. Foam can carry accumulated fiber and undispersed filler or color onto the wire contributing materially to such things as press breaks and dandy build-ups. Entrained air, on its way to appear as foam spots in the finished sheet, is noticeable on the fourdrinier wire as scumminess, bubbles being apparent on close observation. In cylinder machines, of course, foam spots, poor formation, ply separation, even vat overflow with accompanying complete loss of the sheet, can be traced in many cases to excessive amounts of entrained air. One researcher has reported 25 p.p.m. CO_2 in a test system as giving trouble in test sheet formation. This is a factor, that certainly would have to be established in individual instances, although the indicated small amount is of interest. This would correspond to less than 1 oz. air per ton of fiber.

In addition to the tendency for foam in headbox, regulator box, beaters, chests, to float stock and fibers to form crusty residues in nonturbulent areas which can subsequently be dislodged to become smears or cause breaks, we should mention the possibility for beater, chest or wire pit overflow, stock pump binding, and difficult consistency control in summarizing wet end foam problems. Considering these factors, it certainly is logical that the condition of the stock by the time it is in the headbox probably has as much or more to do with the sheet quality as wire travel. Most headbox designs seem to offer attempts to separate air from fiber although most of such air—if not released by showers at the surface finds its way back down the front of the headbox and back with stock as surface and internal froth.

FOAM CONTROL IN PULP MILL

Our discussion is concerned with foam and foam control in the paper mill, but we hope we will be permitted to mention the pulp mill briefly so that we can keep in mind the effects of pulp mill operation on paper mill foam problems; and so we do not lose sight of the possibilities for reduction of paper mill foaming through suitable foam control measures in the pulp mill.

Antifoam formulations are used in many of our modern pulp mill washing and screening operations as well as to control the more obvious effluent foams. This would include the sulphite, kraft, semichemical, and even the groundwood pulping processes. From the housekeeping viewpoint—washer, vat, or chest overflow and low screen efficiency have most often introduced foam control to the pulp washing operation. Probably more important, however, is the fact that if entrained air can be reduced to a minimum, the mill can, if not actually increase washing and screening capacity, make washing sufficiently more uniform that pulp tackiness and foam problems due to residual spent liquor can be materially reduced.

Benefits of efficient foam control in the pulp mill, while most evident in integrated mill operations are apparent in mill operation itself, and in market pulp as well.

PAPER MILL FOAM CONTROL

We have touched on the benefits of uniform, well washed stock from the pulp mill, and will consider now what is being done in the paper mill to keep undesirable effects of foam at a minimum.

The Deculator and the Vortrap Degasser which mechanically accomplish stock deaeration are familiar to most of us; and many of us have either conducted or discussed system studies in an effort to minimize air entrainment tendencies of some paper machine systems. Because of the complex nature of the paper mill system and the fact that the chemically stabilized foams generally encountered are hard to break down mechanically, many more mills than not find it not only helpful but necessary to use chemical antifoam formulations (generally emulsifiable combinations of hydrocarbons, alcohols, fatty acids, and various surface active esters), which frequently are specifically formulated for particular applications.

Compatible and readily blended starch or resin defoamers are generally included in the size press formulation, and small amounts of properly selected defoamer applied at the chest if required, or at the headbox, fan pump, or wire pit to control paper machine foam. In some instances, dilute antifoam emulsions have been applied by spray, directly to the sheet with good results. Attention to application techniques is important, small amounts at more than one point frequently doing a better job than heavier dosage at a single area.

Depending upon the severity of the foam problem, and generally even to a greater degree on mill procedure pref-

erences, defoamers are currently applied, directly or through flow control equipment, from stock emulsions or through one of several types of currently available application systems that readily pump liquid, and fluid paste formulations from bulk storage or supply drums if desired with varying of control over feed rate and emulsion concentration. This does not mean, of course, that an automatic handling system lacks control features; on the contrary, systems vary from relatively effective but difficultly controlled aspirator feeders or eductors to positive displacement systems which include strict flow and concentration control, and often even recording flow meters and instrumentation designed to vary defoamer flow with foam changes in the system.

Such variation exists in the manner and degree of air entrainment in stock that these seems to be no one "best point of application" for paper machine foam control. Headbox or wire pit surface foam, although frequently not so troublesome as less apparent froth in the sheet unless stock and filler residues are floated or overflow occurs, can generally be controlled by headbox addition if turbulence is such that uniform dispersion is possible, or by application of antifoam at the wire pit or fan pump. Troublesome wire foaming while generally reduced by headbox, wire pit, or fan pump defoamer application has been known to respond to a split application. Small additional applications have been found helpful in some instances in a machine chest or occasionally in a wire spray; and although rarely, once in a while in a beater. It is, of course, necessary that a single effective point be found if possible to minimize the added control required for more than one point of application.

Although techniques vary, the application of dilute defoamer or surface active material directly to the sheet has been found, on some grades, to have a beneficial foam control, formation, and drainage effect. Considerable amounts of work have been done, in this country, and abroad which has involved different nozzle types, chemical formulations, and application assemblies.

The blended chemical defoamers seldom seem to exert a single "bubble-breaking" effect, but rather are felt to concentrate at foam interfaces where rapid changes in surface tension occur, foam stabilizer is displaced from the film, or drainage is accomplished through equilibrium breaking combinations of surface properties.

Undesirable side effects, incidentally, such as reduction in sizing or sticking at presses are seldom associated today with anything but improper defoamer choice, or careless or excessive use.

There have been differences of opinion as to the use of increased amounts of alum to control foam. The feeling today is that, while some initial benefits are sometimes noted, the increased acidity is quite apt to reduce the size of the bubbles making an even more stable foam than initially presented the problem.

Evidence of the frequently bewildering behavior of foam exists in the results of efforts to control many foams thermally. Heat logically should evaporate volatile material from the film; changing surface active agent concentration in the surface film, and certainly surface viscosity should be lowered, further contributing to the instability of the foam system. While there are instances where this technique has been helpful, we are aware too of instances where foam problems have actually been magnified by increased temperature.

It is entirely possible that we will someday find sonic or nuclear foam control to he helpful. Certain sound frequencies have been reported as destructive to foams, and alpha particles from a polonium source are said to have been found to be destructive at a rate of something like a tenth of a bubble per alpha particle.

We believe, nevertheless, that versatility in points of application, (important in controlling foam ahead of mechanical deaeration installation as in machine chest build-ups) and the advantage of intermittent use where possible, coupled with their combined attack on foam formers and stabilizers in most cases make today's compounded defoamers an efficient answer to housekeeping and production problems where the furnish has air entraining tendencies and major plant design changes to correct such things as defective or excessive agitation or pumping of the stock are not economically possible.

When we consider the problems that can occur in a mill where foam control has failed, all the currently used control procedures, mechanical and chemical, have to be regarded as very vital to the industry. In thinking of control procedures, we must bear in mind that foam problems in two mills—or even in two machine systems, although they may seem alike, can require very different manners of treatment. Optimum control can best be had through careful study and evaluation of suitable foam control products and application procedures under actual mill conditions.

CONCLUSION

While we believe there certainly will be a day when foam and some of the other trials of the papermaker will be lessened, foam will probably continue to be troublesome for some time to come and efforts will continue to be directed toward more efficient control and, we hope, something approaching greater knowledge of the science of foams. Vast amounts of work have been done, but we really know much too little.

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Felt Cleaning: Its Effect on Felt Performance and Felt Life.—Abstract

James L. Hanchette

A PRACTICAL discussion dealing primarily with specific histories of the effects of felt cleaning upon felt performance and life. Mention is made of various felt plugging agents and means of effectively removing or controlling them. The talk is mainly concerned with chemical aspects of the above, although mechanical influences are also discussed. Slides will be used for illustration and written supplementary information will be available for those in the audience who wish to have it.

JAMES L. HANCHETTE, Huyck Felt Co., Rensselaer, N. Y.

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Melt Index and Its Significance in Extrusion Coating

F. R. Lehman and R. L. Erratt

Melt index is one of the most common parameters used in describing polyethylene resins. However, there is some misunderstanding of the nature of melt index, and in relating melt index data to specific properties of polyethylene. Therefore, in this talk we would like to discuss melt index, and relate what effect melt index has on physical properties of polyethylene, extrusion coating or application properties, and properties of polyethylene as coated on a substrate.

First, we would like to review melt index with you. Melt index is an approximate measure of polyethylene flow in the molten state. Numerically, it is grams of polyethylene extruded in 10 min. through an orifice 0.0825 in., diam., 0.315 in. in length, at 190°C. under a total mass of 2160 g. Melt index describes the flow properties of polyethylene at this arbitrarily chosen set of conditions. A measurement such as this is of value since polyethylenes are processed in their molten state. Melt index is determined using the method specified under ASTM Designation D 1238–52 T. Instead of going through this method step by step, we would like to acquaint you with the equipment used for melt index determinations. Figure 1 is a schematic diagram of a melt indexer. The essential parts are a steel cylinder surrounded by heaters and insulation. A piston with the proper weight is used to force the molten polyethylene through the orifice. A thermometer is placed in the body of the melt indexer so temperature can be accurately determined. Using the equipment described and following the ASTM procedures, melt indexes of polyethylenes can be determined with an accuracy of ±8% on duplicate samples.

To give a more complete picture on melt index, we would like to relate what governs the melt index of different polyethylene polymers. The most dominant factor is that of molecular weight. As the average molecular weight increases, melt index decreases; or like many other polymers, as molecular weight increases so does the viscosity. Other factors that influence melt index are molecular weight distribution, number of side branch chains and other variables in chemical structure. In the manufacture of polyethylene, melt index is controlled and dictated by manufacturing conditions of pressure, temperature, catalyst, monomer purity, and type of equipment.

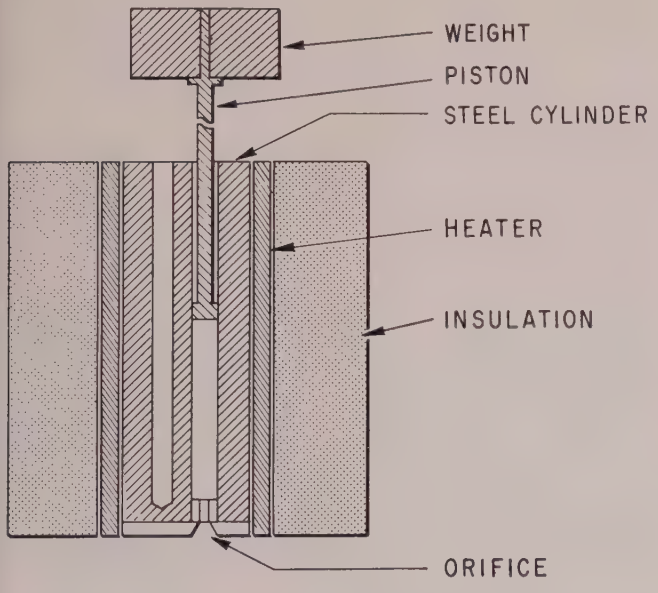

Fig. 1. The melt indexes

Since melt index is a measure of the flow of polyethylenes, a discussion on melt index without mentioning the type of flow which polyethylene exhibits would not be complete. The flow of molten polyethylene is non-Newtonian in nature. Its viscosity drops rapidly with an increase in shear stress. Due to this and other reasons, polyethylenes with identical melt indexes and densities could have widely different flow properties at conditions used for fabrication. Melt index does not completely describe the flow properties of polyethylene. This is true since melt index tests as normally run are not representative of material flow in the extrusion coating process; because, the shear rate and temperature in the melt indexer are much lower than encountered during extrusion coating. When comparing the flow properties of polyethylene on the basis of the melt indexes, most accurate comparisons can be made if polyethylenes are produced by the same manufacturing process, conditions, and equipment.

With this discussion on melt index, we would like to show what changes in the physical properties of polyethylene can be expected with a change in melt index. To illustrate this, we have run physical properties on a group of polyethylenes which encompass the melt index range commonly encountered for extrusion coating. To make these data as meaningful as possible, materials tested were all produced by the same manufacturing process. Table I gives the comparison of the material. The test methods which were followed to determine the results are listed by their ASTM test method.

Five materials with melt indexes ranging from 1.5 through 12 were selected. Their densities are essentially the same. First of all, as melt index increases, the viscosity of the molten polyethylene decreases as shown by melt viscosity data. Melt viscosities were measured using a Dow Caplastometer at a temperature of 440°F. and 700,000 dynes per sq. cm. shear stress. These conditions are much closer to those fabrication than conditions of a melt indexer.

As melt index increases, the ultimate tensile strength decreases. Tensile strength is not so important for extrusion coating as it is for free film since tensile strength of coated products usually is supplied by the substrate.

Elongation decreases only slightly with an increase in melt index. The decrease in elongation over the melt index range of materials used for extrusion coating is not great enough to cause concern.

Low temperature brittleness increases slightly with increase in melt index. Perhaps more clearly stated, polyethylene's toughness at cold temperatures decreases with an increase in melt index. This also is not of great concern, since polyethylenes of this type or density have adequate low temperature flexibility for most coating applications.

The Vicat softening point decreases with increase in melt index. This can be of importance, in that it is somewhat of an indication of heat seal response. Heat seals can be affected at lower temperature for high melt index materials.

Hardness decreases slightly with an increase in melt index. This change is so small that it is of little concern.

Now we would like to turn our attention to the effect melt index has on extrusion coating or application properties. To obtain these data, extrusion coating properties were determined for the same group of resins which were used for the physical property determination. The extruder-laminator used for this study is described in Table II.

The output rate was determined for the resins at screw speeds ranging from 20 to 96 r.p.m. as shown in Fig. 2. The extruder conditions were allowed to reach equilibrium before output rates were determined at the different screw speeds.

F. R. Lehman and R. L. Erratt, Dow Chemical Co., Midland, Mich.

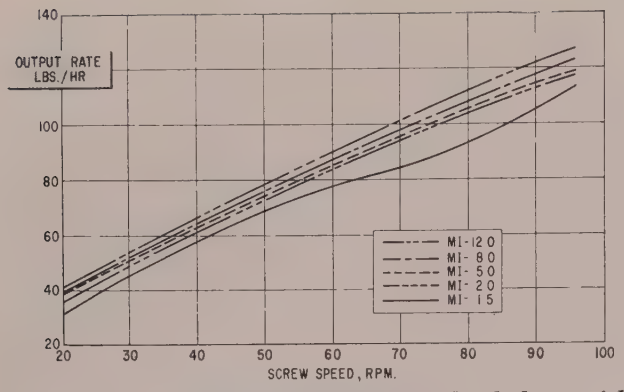

Fig. 2. Output rate vs. screw speed for polyethylenes with different melt indexes

Heater settings were held constant during output determinations. As the melt index increases, output rates increased. The output for a melt index 12 polyethylene was from 10 to 20% higher than for a polyethylene with a melt index of 1.5.

was determined for the same group of resins. There are several types of failures which can occur as a resin approaches its drawdown limit. They are edge tearing, nonuniform coatings (both in machine and cross-machine direction), nonuniform coatings mainly in the machine direction, and a complete break of the plastic web. In the case of the resins evaluated, failures noted were either edge tear or a break in the plastic web. The end point was taken as the point just prior to failure. Results of the drawdown tests are given in Table IV in general, as melt index increases drawdown increases. The only instance where we encountered edge tear was with the 1.5 melt index material, and the edge began tearing shortly after 70 f.p.m. With the other resins, the failure was noted as a break in the plastic film.

The data presented concerning extrusion coating or application properties are quite straightforward without indications of reversals. This is due to the fact that the polyethylene resins which were used were all made by the same process, varying in only melt index. As we have indicated, extreme reversals can happen when comparing polyethylene resins of identical melt index which are made by a different process.

Table I. Physical Properties of Polyethylenes with Different Melt Indexes

Melt index	...	1.5	2.0	5.0	8.0	12.0
Physical properties	ASTM test method	...	...	...	...	...
Density, g./c.c.	Gradient column	0.916	0.918	0.916	0.917	0.916
Melt viscosity[a] η_7, poises	...	5070	4000	1610	1150	960
Ultimate tensile, p.s.i.	D412–51 T	1900	1850	1600	1500	1450
Elongation at break, %	D412–51 T	550	550	500	500	500
Low temperature brittleness, °C.	D746–55 T	-65 to < -70	-65 to < -70	-40 to < -70	-40 to < -70	-35 to < -65
Vicat softening temp., °F.	...	185–205	185–205	180–200	180–195	180–190
Hardness, shore D	D676–55 T	52	52	50	50	50

[a] Dow Caplastometer at 450°F., 700,000 dynes/sq.cm. sheer stress.

All polyethylenes neck-in to a certain extent when they are drawn away in film form from a die. Neck-in is related to beaded edge. The greater the neck-in, the greater the beaded edge and therefore, more trim loss results. It is desirable to keep neck-in at a minimum. The conditions used for determining neck-in for the different melt index resins were 24-in. film width at the die, 610°F. polymer temperature, output rate of 35 lb. per hr., $3^1/_2$ in. distance from nip to die, and a web speed of 120 f.p.m. These conditions produce a coating weight of approximately 7.2 lb. per 3000 sq. ft. or 0.5 mil. Table III shows the neck-in results. In general, neck-in increases with an increase in melt index. There are other factors which determine neck-in, but these were held as constant as possible in an effort to show the effect of melt index on this property. The neck-in for the 1.5 melt index material could not be accurately compared since there was a certain amount of edge tear before the speed of 120 f.p.m. was reached.

Table II. Extruder-Laminator Description

Extruder	
screw diameter	$2^1/_2$ in.
screw type	Metering
length to diameter ratio	16
screen pack during study	40/80/120/40
screw during study	Neutral
Die	
v-shaped sheeting die	28 in. adjusted to 24 in. web with deckles for study
nip distance	$3^1/_2$ in.
Laminator Speed Range	0–520 f.p.m.

The drawdown or hot extensibility is the factor determining how fast and how low coating weights can be applied. To illustrate the effect of melt index on this property, drawdown

The physical properties of polyethylene coatings are affected only slightly with a change in melt index. These properties will be discussed in general, since it is almost impossible to do this using meaningful data. A change in

Table III. Total Neck-In of Polyethylenes with Different Melt Indexes

Melt index	*Total neck-in, in.*
1.5	...
2	$^7/_8$
5	1
8	$1^1/_2$
12	$2^1/_2$

density of polyethylene resins has a far greater effect on properties of coatings such as permeability, grease resistance, softening point, blocking, and slip than does a change in melt index. For example, a change in density of 0.003 units has as much effect on these properties as a change in melt index from 1.5 to 12 does. Table V gives, in general, how melt index influences properties of coatings.

Table IV. Drawdown of Polyethylenes with Different Melt Indexes

Melt index	*Drawdown, f.p.m.*	*Approx. coating weight, lb./sq. ft.*
1.5	70	12.5
2	175	5.0
5	320	2.7
8	380	2.3
12	440	2.0

In summation, the accuracy for determining melt index of polyethylene resins on duplicate samples is ±8%. Polyethylenes having identical melt indexes and densities may

have widely differing flow properties at extrusion coating conditions. Meaningful comparisons on a melt index basis can be made only if the polyethylenes are made by the same process and in the same equipment. Physical properties of

Table V. Melt Index Influence on Coating Properties

As Melt Index Increases:	
Resistance to water vapor transmission	Decreases slightly
Resistance to greases and chemicals	Decreases slightly
Resistance to gas transmission	Decreases slightly
Adhesion	No noticeable effect
Blocking resistance	Decreases slightly
Heat seal response	Becomes better
Slip	Decreases slightly

polyethylene such as tensile, elongation, low temperature brittleness and hardness change little with a change in melt index. This change is of little significance in extrusion coating. Melt index has a definite effect on application properties such as output rate, neck-in and drawdown. The properties of polyethylene coatings are affected only slightly by a change in melt index. Melt index can be used only as a rough guide in comparing materials from various sources.

Presented at the meeting of the Empire State Section of TAPPI held in Lake Placid, N. Y., June 11–13, 1959.

Survey—Emulsion, Solution, and Extrusion Coating

C. G. Morse

Inasmuch as the scope of this paper is quite wide and in covering the problems involved in the three types of coating applications—emulsion, solution, and extrusion coating—it will be necessary for us to present this paper to you in an outline form and to explain parameters in order to limit our paper time. Since the paper will be presented this morning and there will be a panel discussion in the afternoon, we will limit our actual paper itself to the parameters as listed and will not go into complete detail at this time. However, during the panel discussion I am sure that any questions any of you might have to ask can be satisfactorily answered. Therefore, the parameters of this paper will be as follows:

1. We are discussing web coating of cylinder and fourdrinier paper board from 0.009 to 0.040 in caliper, widths of from 16 to 60 in., coated at speeds of from 150 to 600 f.p.m. This is web coating and the products of this coating operation will be converted into component parts, which must be automatically assembled on high-speed production equipment.

2. Our points of discussion will involve food container coatings, particularly coatings used in the dairy industry and related products.

3. We shall limit this discussion to the three basic coating methods, as follows: (a) water dispersion or emulsion, (b) organic solvent solution (room temperature), and (c) extrusion coating or what is known as extrusion lamination, or hot melt coating of paper product.

4. We shall also limit the discussion of each to three basic pieces of equipment, as follows: (a) emulsion for the water dispersion or emulsion—air knife coater, (b) solution for organic solvent solution coating—a reverse roll coater, and (c) extrusion for extrusion coating—a standard extrusion coater setup.

We must assume normal adequate unwind and rewind equipment used with each one of these pieces of equipment and, of course, the degree of automation, such as flying splice equipment and so forth depends upon the needs and requirements of the individual industry.

5. *Finished Product Requirements.* The parameters for finished product requirements have been set up in more or less of a chart form involving the three methods of coating and the requirement, as we see it, to furnish the best finished product for our particular use. This, of course, would involve the production of any number of food containers, such as our Sealking paper milk bottle, our round containers, our Bulkan containers, and our nested (or Nestyle) type containers.

C. G. Morse, Sealright-Oswego Falls Corp., Fulton, N. Y.

REQUIREMENTS OF FINISHED COATINGS

Our company plastic coats paper for both decorative and functional reasons and we combine paper as the low-cost strong substrate with various plastic materials to achieve the following results:

1. Resistance to water, grease, add food product penetration.
2. Resistance to water-vapor transmission into the paper.
3. Improve the general appearance and feel of the container.
4. To provide physical resistance to scuffing, abrasion, and bending.
5. To provide a surface plastic which can be heat sealed.
6. To provide a coating which is odorless and tasteless.
7. To provide a surface which has good flexibility and can be fabricated on automatic equipment.
8. To provide a surface which will be nontoxic and approved by Pure Food and Drug Administration for food contact use.

These are our broad, general requirements for coating materials and we are listing them in chart form and will give brief descriptions concerning each point above, relating to it the method of coating, such as emulsion, solvent, and extrusion coating, which is shown in Table I.

We are also listing, in Table II, the various properties which we are looking for, broken down into: (1) physical, (2) chemical, and (3) miscellaneous, and we explain briefly in this table the various properties of an emulsion, solvent and extrusion cast coating. We shall refer to this table in our discussion concerning each coating method under point 5—Finished Product.

Table I

	Property	*Coating method* — *Emulsion*	*Solution*	*Extrusion*
1.	Water	Fair—Good	Good	Excellent
	Grease	Excellent	Fair—good	Fair—good
	Food product	Good	Good	Good
2.	Moisture vapor penetration	Poor—fair	Fair	Excellent
3.	Appearance	Good gloss	Good gloss	Good gloss
	Feel	Good	Good	Good
4.	Scuff resistance	Good	Good	Good
	Abrasion resistance	Good	Good	Good
5.	Heat seal	O.K.—good Some variation	O.K.—good	O.K.—good
6.	Odor	Fair	Fair—good	Excellent
	Taste	Good	Good	Good
7.	Flexibility	Good	Fair	Good
8.	Toxicity approval	Some problems	Some problems	O.K.

We shall now discuss the three methods of coating and will cover the basic points: (1) materials, (2) materials handling, (3) coating and drying equipment, (4) general problems, (5) finished product requirements, and (6) summary concerning future applications.

EMULSION OR LATEX COATING

Materials

We must again establish a few parameters insofar as the raw materials discussed in this paper are concerned and we are talking here about emulsion or latex type materials in the 40 to 60% solids range, which are compatible with, and will heat seal to, vinyl solution coating resins, since this has been our experience. This would involve vinyl chloride emulsions,

Table II

	Emulsion	*Solution*	*Extrusion*
1. Heat Seal	O.K.—some problems due to plasticizer	Good	Good—problem if treated
2. Blocking	Fair—some problems even with good drying—generally soft	Good—but some problem at elevated temperatures	Excellent
3. Light and heat discoloration	Fair—film darkens some	Fair—good Some darkening	Excellent
4. Toughness	Excellent	Fair—on brittle side	Excellent
5. Flexibility	Excellent	On brittle side	Excellent
6. Adhesion	Excellent	Fair to good	Fair to good
Chemical			
1. Water resistance	Fair	Good	Good
2. Acid and alkali resistance	Good	Fair—good	Excellent
3. Oil Resistance	Good	Fair	Fair—good
4. Water vapor transmission	Fair—poor	Fair	Excellent
Miscellaneous			
1. Odor	Fair	Good	Good
Taste	Fair	Good	Good
Toxicity	Some problems	O.K.	O.K.
2. Clarity	Poor—darkens	Fair—good	Good
3. Cost/lb.	Highest	Intermediate	Lowest
4. Gloss	Good	Good	Fair—good
5. Stability of resins	Fair—good	Good	Good
6. Printability	Fair	Good	Good

vinyl-vinylidene chloride emulsions, acrylic emulsions, and modifications of these general materials.

Materials Handling

Shipments are normally made in 50-gal. drums, tank truck, or tank car. This requires storage at the manufacturing point in lined or stainless tanks, which must be easily accessible for clean-up and washing. These tanks also must be stored indoors or be insulated or heated in some way to prevent these aqueous materials from freezing in winter months. Special stainless steel and special pumping equipment is needed to handle these latex materials to prevent breakdown due to friction. This pumping equipment is rather costly and delivers material at low rates and volume. As delivered, these materials have high solids and low viscosity (50% solids, 25 to 50 cp. viscosity), but have the added disadvantage that at least 50% of the weight of material handled is water and freight costs must be paid on this material. Mixing or addition of pigments or other additives is fairly simple in an emulsion system and a batch process is necessary. Stainless steel or other corrosion resistant coating equipment is needed and, normally, the materials must be handled on a volume basis, because it is difficult to weigh and handle these materials any other way. Because of the dangers of breakdown and freezing, it is not possible to maintain too large an inventory of any latex material. There is no danger from explosion or fire hazard, and consequently no explosionproof or specialty type handling equipment is necessary and no solvent recovery equipment is needed. Batch mixing at or near the coating operation is recommended.

Coating Equipment and Drying

Air knife coater does the best job and provides an excellent coating. At least 50 gal. are needed in the tank of an air knife coater. There are some foam problems. Reverse roll coaters have been used, but there are many problems with doctor blade pressure breakdown of latex material, causing streaking; edge dams cause buildup and leakage; dry material on doctor blades and dams drops into latex and will not redissolve; we have found quite a large percentage of waste and down time due to the above conditions, as well as some foaming problems due to reverse roll action. Because of the very low viscosity and high solids content, it is very difficult to maintain low coating weights with emulsion coating. The proper drying of a latex cast coating has always been the most difficult problem. We need quite a bit more B.t.u.'s of heat to remove water than we do an equivalent amount of solvent, and this causes a slowdown of our coating equipment because of slower drying. Maximum speeds of drying with emulsions have been about 150 f.p.m., compared with 250 to 300 f.p.m. on the same equipment using solution coating.

General Problems

The biggest single problem in coating with latex on raw board stock is involved with the curling of the paper stock in wide widths due to the wetting agent in all of these lattices which causes curling. Moisture variation, and variable fusing across the width of the board, in tunnel-type driers, causes upcurl at the edges. Only fair control of the coating weight is possible, and it is difficult to get a lightweight coating down to $^1/_2$ mil or less continuous closed coating, especially on raw board stocks. We have found that precoating with a solution coating, prior to latex coating, is necessary at times and this reduces the penetration of the latex and wetting agent, gets around the curl problem, and allows for better protection with a lighter film and faster drying. Viscosity control at any given solids has always been a problem at best and the use of thickeners has been utilized. These materials are characterized by very high solids and low viscosity. There has also been some difficulty in obtaining complete approval of these materials on the basis that they contain, not only resin, but plasticizer and wetting agent, which must be approved from a toxicity standpoint.

Finished Product

We refer you to Table II and the points which we have outlined under "emulsion." We get only fair water resistance and these films tend to rewet very quickly due to the presence of wetting agent in the film, which also is in the paperboard stock. Moisture vapor transmission is sometimes good, but the grease resistance is excellent. As we have pointed out, the approval problems are quite complex, involving approval of wetting agents, resins, plasticizers and other additives, and the dry resin cost runs to 40 to 50¢ per lb. and the mileage is not extraordinary, in spite of the higher solids.

Future

Surveying present latex materials, we do not see too much of an application in our process to the use of these materials, due to the problems that we have pointed out above of handling, curl, cost, and slower production speeds. Not the least

Table III

	Emulsion	*Solution*	*Extrusion*
Materials			
Resin, lb.	100,000	100,000	100,000
Lacquer or latex, gal.	21,500	50,000	None
Solids, %	50	22	100
Av. cost/lb. dry resin	0.40–0.50	0.30–0.40	0.35–0.40
Cost/100,000 lb., $	4000–5000	3000–4000	3500–4000
Makeup solvent costs	None	2000	None
Materials handling			
Mixing and blending ($0.10/gal.)	2150	5000	None
Storage costs	Highest	Medium	Lowest
Coating and drying			
Coverage—lb./M sq. ft./1 mil	6.2	7.04	4.78
sq. ft./#/1 mil	163	142	209
S.G. dry resin	1.26	1.36	0.92
Average speeds, f.p.m.	100–200	200–400	300–600
Heat requirements	More B.t.u.	Less B.t.u.	...
Cooling	(Depending on heat input—all need some cooling)		
Miscellaneous costs			
Mixing equipment	High	High	None
Storage tanks	Special—higher cost	Medium cost	None
Pumps and piping, etc.	High cost	Medium	None
Explosionproof equipment	Not required	Required	Not required
Manufacturing building area	Large area	Large area	About $^2/_3$ area
Solvent recovery equipment	Not required	Required	Not required
Insurance costs	Low	High	Low
Maintenance and repairs, etc.	High	High	Low

of our problems is obtaining proper approval from government authorities whose standards are becoming more and more difficult to meet. We anticipate possibly some specialty applications, but no large volume usage of these products in our operations.

SOLUTION COATINGS

Materials

We must again establish parameters for the materials which we will discuss here and we are talking about organic solvent solutions made under room temperature conditions of dissolving the resins in organic solvents at solids of from 20 to 30% normally in common solvents, such as acetone, with a viscosity range of from 100 to 300 cp. Our basic raw materials have been the vinyl chloride-acetate copolymer resins and we have also worked with the vinyl-vinylidene chloride-type materials.

Materials Handling

The dry resin is purchased in 50-lb. bags or in bulk shipments. Solvents are obtained in tank car quantities and stored underground for use. The solvents and lacquers can be stored in ordinary iron tanks and, depending on local laws, normally must be underground storage. This allows for at least a 30-day inventory of raw materials and a good inventory of finished lacquer. To utilize this solution coating method it is necessary to have lacquer manufacturing facilities involving proper dissolvers or mixers, storage tanks, pipe lines, pumps and so forth, and as pointed out it is possible to maintain a 30 to 60-day inventory of finished lacquer and possibly a 30-day inventory of resinous and solvent materials. Standard pumps can be used for handling the lacquer materials and the material is much lower solids (30% or less) but higher viscosity than the latex types previously discussed. Solvent recovery equipment is a must if we are using large quantities of these materials and it involves quite a high capital investment and rather involved operational equipment to keep up. A further disadvantage in materials handling of these type materials involves explosion and fire hazards and all equipment must meet Class 1 Group D requirements.

Coating and Drying Equipment

Our experience has indicated that the reverse roll coater gives the best possible control of coating weight down to the nearest $^1/_{10}$ of a mil dry film coating on paper, but we must control the viscosity and the temperature of the lacquer and recirculate it at the coater head. There are no curl problems with solution coating and we obtain excellent margin and edge control. There is a wide range of viscosity and solids content available to meet any changes in production or variations in the substrate stock which might require viscosity or solids variations. We have found that we have been limited to a one-pass operation maximum of 0.5 mil coating, due to drying and blistering problems. Adequate and good solvent drying equipment must be used and we have utilized different types of drying equipment to effect proper removal of solvent, such as indirect gas-fired ovens, Dawson-type electric air heaters, and even the Sill-type electric panel-type heaters have been utilized. Drying of solvents such as acetone is possible at speeds up to 400 f.p.m. but we have found that one of the difficulties is involved in a two-side coating in which we coat both sides of the web and solvent is trapped to cause "blow through" on the second pass coating, unless great care is taken in the second pass coating operation. Of course, solvent recovery is a *must* in this type of operation if it is to be economical and this involves further capital expenditures and maintenance costs.

Finished Product

We again refer you to Table II covering the various requirements and indicating the good properties of the solution type coating. This method gives an excellent, low-cost product, which meets practically all of our requirements, and which for the past 10 years has been the standard of production for the Sealright Co. The dry resin costs run from 32–38¢ per lb., mileage is fair, and we get an excellent product. General resistance of the film is good, although the moisture vapor transmission is not quite good enough for some packaging requirements. It has provided an excellent coating for many of our single-service containers and closures.

Future

We believe that there is still an excellent future for many of these solution cast coatings. Control, as we have pointed out, is very versatile and although the coatings are not outstanding in many ways, still a fine product can be manufactured. We feel that in many case this solution coating will be replaced by the more attractive and economical aspects of extrusion coating. Cost is the big factor in any of these decisions and expansion of plant, which requires added cost of equipment and capital outlay, would make this operation prohibitive.

EXTRUSION COATING

Materials

In this discussion we are limiting ourselves to the low density polyethylene extrusion coating resins of the density 0.92.

Materials Handling

The dry resins are received in 50-lb. bags or large rubber Sealdbins containing 10,000 lb., which can be stored outdoors and eliminate usual inside handling and warehousing. There is no necessity for a tank farm, pumping station or lacquer manufacturing, mixing or handling facilities, and no solvent recovery system. From these standpoints alone of savings in materials handling equipment and capital expenditure, this system of coating is much superior to the two previous ones discussed.

Coating Equipment

A standard extruder is used in combination with a laminating type head and there is no need for lacquer handling equipment of any kind. It is merely necessary to convey the resin to a hopper on the extruder. The control of the coating weight and application is simple and easy and merely requires the proper application of resin, temperature, extruder speed, and lamination pressure to obtain excellent coatings. Unlimited speed is available because of this hot melt application, which requires only cooling on a chill roll and unlimited coating weights from 0.3 to 2.0 mils is possible, at speeds up to 600 f.p.m., depending upon the size of the extruder and width of the paper to be coated. No drying is required—only cooling—and this also provides for an extreme saving in capital expenditure.

Finished Product

We again would refer you to Table II and show you that in all respects we obtain excellent properties. The dry resin costs are very low at roughly 35¢/per lb. and we get excellent mileage and coverage. Properties of the finished film are excellent and it more than meets the requirements for a protective film in our industry.

Future

Because of the above outstanding good points of an extrusion coating operation, we feel that there are unlimited future possibilities in all board coating fields. As you can see from the foregoing, savings in capital investment alone are quite sizable and there are many other advantages, such as higher potential speeds, small equipment floor space, lower base resin cost, better mileage, reduced odor, taste, and approval problems. We foresee an excellent future for this product in the container and closure industry.

ECONOMICS OF COATING OPERATION

Final finished cost of the single service product is the actual criterion for choice of coating operation and we can consider these three operations from this standpoint. In figuring the economics of any coating operation it is necessary to take into consideration all of the variables involved, such as the base resin cost, mileage, cost of the preparation, additives, material handling, solvent recovery and other extra costs, general coating cost, involving speed, productivity, and efficiency which involve proper drying, and other hidden costs. Waste and trim costs are most important also. Then, of course, there is the capital investment problem involving storage tanks, building for lacquer manufacturing and storage, driers, length capacity, and so forth, general plant equipment, that is, required square foot floor space for a given coating operation or installation, solvent recovery plant, buildings and duct work, miscellaneous pumps, underground storage tanks, and so forth, connected with the coating operation, and of course, explosionproof equipment, motors, and finally insurance costs which are involved with this type of operation.

In order to draw this all into one conclusion, we have attached an hypothetical operation involving the use of 100,000 lb. of dry resin per month, and this is covered in Table III showing the materials needed and other variables.

In conclusion, we have presented herewith three typical coating operations and some of the comments which we have to make insofar as we would compare emulsion, solution, and extrusion coating methods. We trust that this survey has given you food for thought as to your own future coating operations.

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Use of Films and Foils in Combination with Paper

P. K. Wolper

It has proved somewhat of an insoluble problem to approach the subject of the use of paper, film, and foil combinations in a way that is both new and worth while. To begin with, we would like to give you the basic propositions on which we want to develop the subject.

First, we intend to limit the discussion of this subject to packaging end uses. Industrial end uses are important—their omission does not infer the contrary. Packaging end uses are, however, more demanding in their material requirements. There is ample evidence in the packaging field for the existence of the almost infinite variety of flexible barrier materials today or that will be potentially available tomorrow or next year.

Our second proposition is obvious and states that neither paper nor the films or foils have a monopoly in the packaging field. In the years before the war, films and foils were minor factors compared to their importance today. The packaging industry is relatively young; and in the early years depended more on the paper industry for supply. The growth of the packaging industry, from the years prior to the war to the present time has developed a lively response from the paper, film, and foil industries alike.

Our third proposition centers about the question on whether the films and foils will or can supplant paper based packaging materials in the future. We think not. Our

P. K. Wolper, Riegel Paper Corp., Milford, N. J.

purpose today is to indicate why we do not believe this will happen. Certain knowledge is not yet granted to any one at this time. The best we can do is to attempt an understanding of the ground rules that have applied to the present time and that will apply in the future.

The ground rules in this subject are the fundamental relationship of any flexible barrier material to the packaging (or industrial) end use.

RELATIONSHIP OF PAPER, FILM, AND FOIL COMBINATIONS TO END USE

Figure 1 attempts to indicate the basic factors involved in this relationship. The product that sells, whether it is a retail package on the store shelf or whether it is an industrial flexible material, is the final criterion—even if rather far removed from our subject. We have attempted to illustrate how the complexes that go to make up the retail package can be isolated and examined. You will note we consider three complexes: (1) packaging material, (2) packaging operation, and (3) distribution complex.

It will be seen that the packaging material is a complex that embraces the substrate material and the equipment and raw materials of conversion or combination. This comprises our basic subject.

Once the packaging material has been produced it becomes one of the factors in the packaging operation. Here there is a relationship between the packaging material, package equipment, and the packaged product. To expand this concept briefly, the product imposes certain requirements upon the packaging material. The packaged product may be dry and hygroscopic or it may be moist. The product may be a liquid, a paste, or a solid. If it is a solid, it may be in the form of granules, powder, or flakes. It may be hard or soft. It may contain sizable amounts of fats or oils. It may require storage under low temperatures. Whatever it is, by its very nature, it will demand certain properties and characteristics in the packaging material.

The packaging equipment available for unit packaging will also impose certain requirements upon the packaging material. Packaging machines are very much like trees. No two trees of the same species are exactly alike. Similarly, no two pieces of identical packaging equipment are precisely alike in their performance. Thus there are not only the gross differences between different types of machines that must be considered but also the minor differences between machines of the same type. A producer of packaging materials must therefore build into his product a degree of versatility or latitude in much the same manner as the photographic producers build latitude in their products to take care of the differences in amateur usage of their product. In addition, and just as important, the packaging equipment will require varying degrees of mechanical strength properties from the packaging material.

We have represented a third major complex to be considered in the final package: that of distribution. Here again we can indicate certain basic relationships that exist. Warehousing and shipping both require considerable engineering in the unit package, as well as in the master pack, to enable them to successfully withstand the environmental conditions that will inevitably be at work.

In considering the complexes of package material, packaging, and distribution, we can approach an understanding of the make-up of the retail package at point-of-sale. To the merchandizing man the retail package itself must have certain elements that are dependent upon and composed of the factors previously mentioned and that also bear a relationship one to the other. The retail package must have certain visual characteristics that include "eye-appeal," brand identification, labeling, and product identification. Secondly, the retail package must have both protective and mechanical functional properties that will preserve both the external integrity of the package and also the quality of the packaged product. The visual and functional properties must be obtained at the lowest optimum cost.

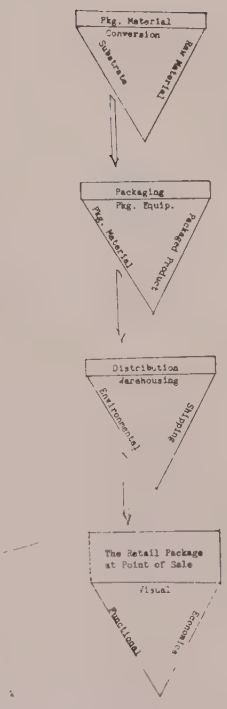

Fig. 1. Relationship of Paper, Film and Foil Combination to End-Use.

It is clear that packaging materials are only one part of the over-all packaging complex. We suggest that changes in other parts of this complex will continue to emphasize material combinations rather than hypothetical all purpose paper, film, or foil.

Table I. Selected Film Properties (1.0 mil)

Type	*Sp. gr.*	*Yield, sq. in./lb.*	*Tensile lb./in.*	*Tear, g.*	*WVTR 100°F.—90% R.H. g./100 sq. in./24 hr.*	*Oxygen transmission cc./100 sq. in./24 hr., 73°F.*
Cellophane (uncoated)	1.4–1.5	19,500	7–16,000	2–10	17.0	0.007
Rubber hydrochloride (Pliofilm)	1.11	25,000	2950–4600	12–1000	0.14	6–39
Vinyl copolymers	1.28	20,750	4230	212	7.5	15
Vinylidene chloride (Saran)	1.2–1.7	16,300	7–15,000	10–20	0.19	5.9
Polyethylene						
Low	0.92	30,100	1500–2500	60–200	0.69	740
High	0.96	28,800	3500–4000	300–400	0.24	280
Cellulose esters						
Acetate	1.3–1.4	22,000	7–12,000	2–25	57	250
Acetate-butyrate	1.2	23,600		3–5	42	...
Polyester (Mylar)	1.38	20,600	17–23,700	10–27	1.0	0.13
Polyamide (Nylon[6])	1.14	24,000	12–14,000	60	10.0	6
Polypropylene	0.90	31,000	4500	...	0.2	490
Polystyrene (oriented)	1.05	25,400	9–10,000	25	3.5	213

PAPERS—FILMS—FOILS

We inferred at the outset that the films, foils, and papers have received more than adequate attention in the literature. You are all aware of the excellent compilations of technical data and information that are currently available from trade journals such as *Tappi; Modern Packaging; Paper, Film and Foil Converter;* and *Package Engineering* as well as from the annual publications such as *Modern Packaging Encyclopedia* and *Modern Plastics Encyclopedia.* Along with these publications there stands the published information from the paper, film, and foil suppliers. The buyers of flexible materials can-

not complain for lack of information, nor can any of the flexible materials suppliers long remain unaware of actual or potential competition. The problem really facing both buyers and suppliers is one of "too much" rather than "not enough."

Table I contains selected information on film properties obtained from this literature. Similar data on the foils are given in Table II.

Table III indicates some of the data available on basic types of paper used in packaging. There are grave difficulties in tabulating the properties of the hundreds of varieties of each of these basic types. On the other hand, to condense the data into somewhat the form shown also has its problems. Table III indicates the expansion of one of the basic paper types, Glassine, into categories by conversion type. Improvements in barrier properties indicated by the limited data presented can be seen by comparing them with comparative data on the base paper or similar data on films.

Table II. Selected Aluminum Foil Properties (Sp. Gr. 2.71)

Gage, in.	*Weight, lb./3000 sq. ft.*	*Yield, sq. in./lb.*	*Tensile, lb./in.*	*Tear, g.*	*WVTR G/100 sq. in./24 hr. 100°F.—90% R.H.*
0.00025 soft	10.5	41,000	..	..	...
0.00035 soft	14.2	29,200	..	..	0.29
0.00050 soft	20.2	20,500	5	10	0.12
0.00050 (hard)	...	20,500	13	10	...
0.00070 soft	28.4	14,600	..	..	0 to 0.07
0.00100 soft	40.5	10,250	10	25–30	0 to 0.03
0.00100 (hard)	...	10,250	27	20–25	...

END USE OF FLEXIBLE COMBINATIONS

Because of the tremendous amount of information available we emphasize relationships of material to end use rather than specific properties of individual materials. These relationships are important to the buyer because only by considering them can he select the best material for his particular end use with a reasonable amount of success. Similarly, these relationships are important to the materials producer in his attempts to make or improve an existing product or to plan or develop a new product.

So far, we know of no single, unconverted all-purpose flexible packaging material. If one runs down the list of principal packaging end uses, Table V, comparing plain or unconverted paper with converted paper, plain films with converted films, and plain foil with converted foil, it will be seen that in each category, the converted material has wider application. This is by definition true of combinations of papers with films or foils, since these are many times similar in structure to the converted basic material.

Table III. Selected Paper Properties

Type	*Weight, lb./3000 sq. ft.*	*Yield, sq. in./lb.*	*Tear, g.*	*WVTR G/100 sq. in./24 hr. 100°F.—90% R.H.*	*Oxygen transmission cc./100 sq. in./24 hr.—S.T.P.*
I. Plain papers					
Kraft	20–100	4320 to 21600	2–2.5 g./lb.	High	High
Vegetable parchment	18–110	3927 to 24000	60–130% b. w.	High	Fair
Glassine	14–60	7200 to 30857	50+% of b. w.	High	Good
II. Converted papers					
Waxed glassine	25/31	13935	50+% of b. w.	0.15	0.3
Solvent coated glassine	22/25	17280	50+% of b. w.	0.5–0.8	4.8
Laminated glassine	45/52	8308	50+% of b. w.	0.2–0.3	1.3

Table IV illustrates an important field in flexible materials, namely the converted films. The omission of coated cellophane from the film data, Table I, may have already been observed. Actually, the nitrocellulose coated cellophane types are among the oldest materials on the packaging scene, while the other coatings on the film are more recent. Today coated polyethylene and polyester films round out this type of material. The future will undoubtedly see more.

Our reference to converted papers and films suggests why papers, films, and foils are and undoubtedly will be used in combination. Combined or converted materials permit the design of packaging materials with an optimum balance of

Table IV. Selected Converted Films Properties

Type	*Weight, lb./3000 sq. ft.*	*Yield, sq. in./lb.*	*Tear, g.*	*WVTR G/100 sq. in./24 hr. 100°F.—90% R.H.*	*Oxygen transmission cc./100 sq. in./24 hr.—S.T.P.*
Coated cellophane					
Nitrocellulose	...	21,000	2–10	0.57	...
Saran	...	19,500	7–15	0.52	...
Polyethylene (1 mil)	...	11,800	16–50	0.69	...
Coated polyethylene					
Saran	...	29,500	60–200	0.79	2.0
Coated polyester (0.5 mil)					
Polyethylene (2.0 mil)	...	10,900	...	...	...

Table V. Flexible Packaging End Uses

	Paper		Film		Foil		Combination
	Plain	Conv.	Plain	Conv.	Plain	Conv.	
Frozen foods	..	x	x	..	..	x	x
Dehydrated foods	..	x	..	x	..	x	x
Bakery products	x	x	x	x	..	x	x
Prepared mixes	..	x	..	x	..	x	x
Cereals	..	x	..	x	..	x	x
Snack foods	..	x	..	x	..	x	x
Shortenings	x	x	x	..	..	x	x
Fruits & vegetables	x	..	x	x	..	..	x
Dairy products	x	x	..	x	x	x	x
Meats and fish	x	..	..	x	..	x	x
Beverages (coffee, tea)	x	x	x	..	..	x	x
Sugar products	x	x	..	..	..	..	..
Candies	x	x	x	x	x	x	x
Tobacco	..	x	..	x	..	x	x
Cosmetics	..	x	..	..	..	x	x
Medicinals	x	x	..	..	..	x	x
Chemicals	..	x	..	..	..	x	x
Soap products	..	x	..	x	..	x	x
Metal goods	x	x	x	..	..	x	x

In the same manner, were one to check the list of major packaging requirements of flexible materials such as heatsealability, strength, barrier properties, and so on it would become evident that properly converted or combined papers, films, and foils can be made to meet all requirements. At the same time, each of the basic materials has some shortcoming in one property or another that exerts a limiting influence on its universal use. In short, it appears that the converter or combiner of paper, films, and foils will continue to hold a major place in the flexible materials field.

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Recent Developments in Wastepaper

R. W. Kumler

In comparing the statistics of the paper and board industry for the years 1957 and 1958, wastepaper stands out as one of the bright spots in the whole picture. At a time when the industry as a whole was just about holding its own, wastepaper consumption increased 2.1%. What is even more interesting is that the per cent of the total fiber furnish derived from wastepaper rose from 26.5 to 26.9%. It is the first time in about 30 years that the ratio of wastepaper to total fiber has increased, except during World War II and the Korean War.

Unfortunately, it is not possible to analyze these figures and pinpoint the grades that show the best performance. The only national statistics of wastepaper consumption come from the Bureau of Census which gives total tonnage, but not tonnage by grades. This should be qualified by saying that, periodically, consumption of total grades is given by class of finished product. It is hoped that some day more complete information can be made available in order that the market trends may be followed in detail.

The volume of consumption of waste paper is influenced by many factors and one of the more important ones is wastepaper quality. With the advent of new technological developments in the way of plastics, adhesives, coatings, and many other types of additives, it has become increasingly difficult for wastepaper merchants to deliver pure fibers or, at least, fibers containing only harmless materials. Many of the unwanted substances are already very familiar to all users of wastepaper, but it is proposed to discuss today some of the more recent developments of which some may not have yet come to the attention of all concerned with the marketing and consumption of wastepaper.

R. W. Kumler, Waste Paper Utilization Council, New York, N. Y.

TABULATING CARDS

Waste tabulating cards constitute a highly prized item among wastepaper users, as shown by the comparatively high price that they command. Up until a few years ago there were few problems in connection with tabulating cards, with the possible exception of wet strength. More recently a number of features have appeared.

An all-plastic tabulating card is being produced which, at first glance, has much the same appearance as a paper card. It sells in an entirely different price range and was designed only for special uses. It is not expected that it will gain a large percentage of the market, but this is small comfort if it is to be mixed with paper cards. On the plus side, it is expected that this card will be given a distinctive marking in the near future, so that it can be readily recognized.

To the regular manila cards there is an added feature in the way of facilities for attaching microfilm records. A rectangular window is punched in the card over which is pasted a sheet of cellulose acetate film coated with a pressure-sensitive adhesive. To prevent the cards from sticking together, the exposed adhesive is covered with a small sheet of laminated waxed glassine. The user of the card removes the waxed glassine and replaces it with a microfilm record. The use of this device is growing rapidly and, while not many of these cards have yet reached wastepaper channels, there is cause for concern about the situation when these cards begin emerging from the files and are placed in wastepaper channels. The manufacturer of the cards has set up a research project with a very large research laboratory in an effort to find means of retaining the advantages of this development without having adverse effect on wastepaper consideration.

Some tabulating card users have adopted the practice of correcting erroneous punchings by covering the perforations with small pieces of plastic tape. Those observed so far have been red in color and were attached with pressure-sensitive adhesive. Here again, the manufacturer of the tape is conducting research with a view to minimizing the impact of the tape on the value of tab card waste.

In the past year unbleached kraft cards have been produced to serve the same purpose as manila cards. The fiber in the cards is perfectly good material, but some of the deinking mills are not equipped to bleach kraft. Those who have multiple-stage bleaching systems find the cards quite acceptable, but discretion must be used on the part of the wastepaper distributor in selecting his customers.

A number of minor problems has arisen in connection with tabulating cards and it can be expected that many more will arise in the future. So far most of those that have appeared have been of little importance, or have been taken care of easily. One particular instance was the attachment of tags to

tabulating cards with a pressure-sensitive adhesive, in which case the generator of wastepaper readily agreed to segregate these cards.

MAGNETIC INKS ON BANK FORMS

For sometime the American Bankers Association has been considering a new automation system for the handling of bank forms. This was finally adopted at the end of 1958 and this year the system is being put into effect. It involves the printing of checks and other forms with magnetic inks comparable to the coatings used on recording tapes. The essential ingredient in these inks is magnetic iron oxide which, in itself, will not likely be bothersome except possibly in the manufacture of certain highly specialized papers.

As presently planned, the printing can be placed in two categories, namely, the printing of checks and deposit slips on the one hand, and the printing of bank statements on the other. The printing on the former category will be light and we are assured by the ink manufacturers that the vehicle is such that no trouble will be encountered in pulping or deinking operations. However, it is expected that individual banks will use this same system on the printing of bank statements, in which case the printing is a different matter. The ink will be applied by the silk-screen process and will appear as either broad or narrow stripes on the backs of the statements. Some banks have already adopted this practice. This printing is very heavy and one printer estimates that the thickness of the film is 0.015 in. Regardless of the nature of the ink this may give trouble to some wastepaper consumers. Furthermore, the development of inks for this purpose is still not complete and there may be changes in the type of ink presently used. Tests are now being conducted on the present inks and a report will be available later, but the development will have to be followed carefully to note the changes that may be made as time goes on. The impact of this project may not be felt immediately because most of the printing will be done on papers that go into files and remain there for 10 to 20 years. However, if we are to forestall future trouble it is important that the problems of wastepaper be brought to the attention of the designers of this automation system now.

FOIL AND PRINTING PAPERS

In the past 2 years there have been many instances of the inclusion of aluminum foil in magazines and newspapers. Certain modifications in postal regulations make it easier to mail publications containing inserts of nonpaper items. Such inserts will usually incur higher postal rates and may appear only in newsstand copies. Nevertheless, this means that magazines must be scrutinized more carefully in the future. One of our advertising friends expresses the opinion that foil will not replace paper as a printing medium since certain additional costs are involved along with difficulties in printing. On the other hand, the suppliers of foil and those who use foil in the manufacturing of packaging materials will want to present their wares in the best possible light and are likely to use magazines and newspapers as means of making the presentation.

A number of newspapers have been carrying ads of foil, including samples. Most of the newspapers involved have been cooperative in segregating the overissues from foil-free copies. In the homes housewives have usually removed the foil samples and, in general, little harm has been done to wastepaper stocks. This fortunate result has been in some measure due to alert action on the part of wastepaper dealers and this vigilance must be continued to protect our very important newsprint supply.

Recently newspapers in some 30 cities in the Midwest have carried insertions of waxed paper. The advertising company has completed its program for this year, but may repeat it at some future time.

BOX TAPES

Tapes for use on the manufacturer's joint in shipping containers have traditionally contained asphalt in their construction. The asphalt is necessary to hold in place reinforcing fibers placed between the two layers of paper to form a strong element of the box. Adhesives for attaching the tape to the box are generally of water-soluble types. Because asphalt is black a demand has arisen for nonasphaltic tapes and practically all tape manufacturers have responded with laminated products that contain no asphalt. However, many of these tapes have, in the place of asphalt, rubbery-type adhesives which are indispersible in mill systems where corrugated waste is used as raw material. This matter has been brought to the attention of the tape manufacturers and a serious study is now being made of means of producing tapes that will present no problem to the consumer of corrugated waste. There is good reason to believe that this problem will be solved in the near future.

CORRUGATING ADHESIVES

A comparatively recent development in corrugating is the use of a combination of resorcinol resin with a small amount of cooked and a large amount of uncooked starch. This combination is applicable under alkaline conditions, produces a strong water-resistant bond, and has become quite popular in the industry. The reception of corrugated waste from this operation is somewhat mixed. Apparently, it is possible to disperse the adhesive to an invisible state with alkali, high temperature, and heavy mechanical action. However, some mills encounter trouble in attempting to handle such waste under their regular procedures. The solution of the problem is not yet clear, but it is hoped that it will be worked out when all the factors become well known.

PRESSURE-SENSITIVE BOX FLAP ADHESIVES

Still in the field of corrugated waste, one manufacturer of corrugated boxes is applying pressure-sensitive adhesives to the flaps so that the boxes may be readily closed, opened, and closed again. In certain other cases it has been recommended that the user of the box employ similar adhesives for this purpose. The manufacturer of the boxes with the adhesive applied at the box plant is marking the boxes with the accepted octagonal symbol bearing the letter "R," so that they will be readily identifiable. However, no plan has yet been developed for meeting the problem of the adhesive applied by the box user, other than the possiblility of securing the use of other adhesives, such as are mentioned below.

PRESSURE-SENSITIVE ADHESIVES

There is good news from the adhesive front. At least five different manufacturers of adhesive materials have, in the past few months, advised that they had under development pressure-sensitive adhesives, some of which are water soluble, others water insoluble but alkali dispersible. With the exception of the Minnesota Mining and Manufacturing Number 405 Repulpable Splicing Tape, and Illinois Adhesive's flying splice product, none of these new materials have yet reached the commercial stage, but there is ground for hope that, in the near future, products will be available which, if used, will go a long way to solving some of the problems of waste paper.

POLYETHYLENE SHIPPING SACKS

The use of polyethylene in connection with the manufacture of bags is growing. Not only is more polyethylene film used for lining or as one of the plies in the bag but polyethylene-lined tape is being used for the closing of the bags. Also, a "polyethylene-based adhesive cord" forms a part of the bag closure. This will call for vigilance on the part of everyone handling old shipping sacks.

WHAT CAN BE DONE?

Peter Hoguet, president of The Econometric Institute, speaking before the National Association of Waste Material Dealers, and quoted in a number of the trade journals, made the following statement:

> "Growth of demand for wood pulp over the years has been due in good part to the ability of the pulp producers to guarantee the quality of their products. To compete successfully the wastepaper industry needs a quality control "program equal to that of the modern pulp mill, in order to insure consuming mills of a steady and dependable supply of quality raw materials."

This is a large order. Many of us have been thinking about it for sometime and it is worth further thought. Can such a goal be realized? It is very doubtful that packers and dealers of wastepaper can set up such a Utopian condition by merely tightening up on sorting methods. Some objectionable materials are not practicably "sortable." Nevertheless, the industry can have what it wants if it wants it badly enough. Much can be done by enlisting the assistance of those who generate wastepaper. Printers, converters, box makers and the like, know what they are applying to paper and board, and if they become informed as to what is and what is not permissible in wastepaper, can help greatly to insure clean stock and relieve the burden of expensive and uncertain sorting. This, of course, calls for an all-out educational program.

THE WASTEPAPER UTILIZATION COUNCIL

The Waste Paper Utilization Council has been organized to strive for the very thing that Mr. Hoguet has suggested. It approaches the over-all problem in several ways. First, it acquaints manufacturers of adhesives, coatings, films, printing inks, and other additives for paper on the requirements of wastepaper users. It is most gratifying to note that most such concerns give serious thought to the problems presented. Many of the printing ink manufacturers have modified their inks to improve the value of printed waste. The development of soluble pressure-sensitive adhesives is another instance of the cooperation of the manufacturing suppliers of the paper and allied industries.

Where materials undesirable from the wastepaper standpoint must be used, the generator of wastepaper is urged to withhold them at the sources. The generator of wastepaper, in most cases, has a financial interest in cooperating with this program because it improves the market for his waste and its price. He knows, too, that the cost of paper is reduced if the mill receives troublefree raw material.

Wastepaper as clean and uniform as virgin pulp seems as unobtainable as the moon, but that is no reason for not trying to reach such a goal. Any progress in that direction is worth while and—who knows? someone is going to get to the moon in the foreseeable future.

Presented at the meeting of the Empire State Section of TAPPI held at Lake Placid, N. Y., June 11–13, 1959.

Plastics—Friend or Foe of the Paper Industry?

H. A. Arbit

A COUPLE of months ago this headline appeared on the front page of a leading business journal "Plastic film fights paper in lush packaging field." This is a fact. Plastic film—the article was referring specifically to polyethylene—is competing vigorously with paper in many packaging areas . . . and taking away business. In such well established paper markets as produce packaging, bread wrapping, garment and laundry bags, paper product overwraps, and agriculture, plastic film has either gained a firm foothold or threatens to do so in the very near future. But, this is only one side of the coin. Today, I would like to talk to you about the other side—where paper and plastics can team-up to boost one another's sales and profits.

First, some figures. Both the paper industry and the plastics industry have grown tremendously over the past 15 years. Paper and paperboard consumption in this country stood at a 17-billion-ton-per-year level in 1943. In 1958, the level reached 30.4 billion tons—almost double. Plastics sales in 1943 were a little over one-half billion pounds. In 1958, sales topped the four and one-half billion pound mark —a 900% increase.

These figures are quite impressive, I think, but let's get a little more specific and talk about paper and plastics combined. Plastics are combined with paper by a number of methods, including impregnating, calendering, roller coating, knife coating, and extrusion coating. Among the more familiar plastics-paper uses would be phenolic-impregnated paper for counter tops, calendered vinyl on paper for lining screwtype bottle caps, roller-coated vinyl for high-gloss magazine paper, and polyethylene-wax knife-coatings for bread wrappers.

Perhaps the biggest plastics-paper success story is the use of polyethylene extrusion coatings. In but a few years, paper extrusion coated with polyethylene has gained considerable stature, particularly in the flexible packaging field. And the future holds tremendous promise. Therefore, rather than try to cover *all* plastics and *all* paper applications of plastics, I am going to concentrate today on polyethylene-paper combinations prepared by the extrusion coating process. We feel that only the bare surface of this product's market potential has been scratched.

In 1950, only about 2.5 million lb. of polyethylene were applied to various substrates by extrusion coating. In 1958, approximately 35 million lb. were used. The forecast for 1963 is for 120 million lb. Paper and paperboard, at present, consume about 63% of all polyethylene used in extrusion coating. About 13 million lb. are coated on bleached kraft, 7 million on unbleached kraft, and 3 million on paperboard. Here is what the future looks like. It is predicted that by 1963, paper and paperboard will account for 80% of all polyethylene used in extrusion coating—96 million lb. for the year.

This estimate is based largely on expected increases in the use of polyethylene-coated food grade board. Candy and bakery boxes, milk containers, general dairy products, dry and granulated powder products, drugs and pharmaceuticals, frozen foods, and hot drink containers are all areas where polyethylene-coated board offers many important advantages. It is not unreasonable to believe that close to 50 million lb. of polyethylene will be extruded onto paperboard by 1963.

We have confidence in these figures. We believe they represent an accurate picture of today's polyethylene-paper market and the potential that exists. But, what is the reasoning behind these figures? Why is polyethylene extrusion coating expected to make such large gains? We see it this way. The decision-makers in your industry will become convinced that polyethylene extrusion coatings offer one of the most practical means of (1) maintaining a hold on large volume existing paper markets and (2) penetrating markets where use of paper is small or virtually nonexistent.

Can we back up this statement? I believe we can—by reviewing specific areas of application. Let's take the first part of the statement "maintaining a hold on large volume existing paper markets."

Here is an end use which is very familiar to all of you—the multiwall shipping bag. Close to three billion multiwall bags—well over 800 thousand tons of paper—are now used commercially each year. Obviously, this is a well-established market for paper, so how can you substantially enlarge paper usage? (Table I) Well, let's look at three of the largest end use outlets for multiwall bags—fertilizer, livestock and poultry feeds, and wheat flour. Combined, these three uses

account for one third of the multiwall bags now in use. But, interest in the all-plastic sack is very high in these fields, and the paper industry must face up to this pressing challenge—How can you clamp a stronger hold on these vital paper markets?

Table I. Major End Uses for Multiwall Bags

	MM Bags	*% Total*
Fertilizers	384	14.0
Livestock & poultry feeds	376	13.7
Wheat flour	140	5.1

A polyethylene extrusion coating—specifically a high density polyethylene coating—offers a practical answer. According to recent tests, high-density coatings give a degree of product protection superior to low-density coatings and competitive with heavy gage plastic sacks. There is little significant difference between the moisture barrier properties of a paper bag with a thin high-density coating and those of a thick all-film bag. Grease and oil permeability are actually superior—and the high-density coating has low slip characteristics, high stiffness and hardness, and excellent abrasion resistance.

Bread wrapping certainly is a timely topic, so let's discuss this market for a moment. Where are the challenges—and how can polyethylene help you meet them? Waxed paper on a pound per volume basis is, of course, the most widely used bread wrapping material. But, the transparent films are gaining. Cellophane, already well established, is making steady progress. And now, that other transparent film—polyethylene—is trying to muscle in as well. Who stands to suffer most from this increased use of transparent bread wraps? Obviously, the paper industry.

But, what about the use of polyethylene in paper wraps to clamp a stronger grip on this market? Polyethylene-wax modifications have been used for years to coat paper wrappers. They give excellent gloss, toughness, improved grease resistance, and reduced rub-off during handling. But, there is a brand new paper plastic entry in the bread wrap sweepstakes called "Mara-Poly." This paper wrapper, a product of Marathon, a Division of American Can Co., has a super high gloss polyethylene-wax combination on the outside and a white polyethylene extrusion coating on the inside. This interior coating gives the wrapper greater opacity—greater "whiteness." Toughness also is increased, and moisture barrier properties are near perfect. The end result is a wrapper that provides significantly better "keeping" qualities. Initial baking industry acceptance of this wrapper has been excellent, and we understand that many bakers who market tested it are placing large re-orders. A worthy reinforcement in paper's campaign to maintain its position of leadership in the bread wrapping field.

This new white coating, by the way, has important advantages for other end use areas of paper. Its excellent appearance and top barrier properties, for example, make it highly suitable for coating low grades of paper and paperboard. This should mean big economy for some applications. A lower cost product can be used without sacrificing quality or performance.

One of the most outstanding examples of paper's success in a market is the milk carton. The bottling industry has really felt the impact of paper here. Not too long ago, virtually all milk was sold in glass. Now paper cartons have better than one half of this 14 billion container market. There is every indication that paper's share of this market can continue to expand. A big stimulus could be the recent development of the polyethylene extrusion-coated milk carton. This type of carton eliminates several of the old gripes about wax-coated paper milk containers. Top protection is provided against leakage, chipping, collapse, and damage from handling. Look for paper to gain more milk business—with the help of polyethylene.

In passing, I'd like to point out that the polyethylene-coated milk carton is competitive in cost with conventional wax-coated cartons. A 3000-unit ream of paperboard requires about 105 lb. of paraffin wax for milk carton construction. The cost for this wax is approximately $10.50. For the same 3000-unit ream, 15 lb. of polyethylene would be needed to extrusion coat the paperboard $^1/_2$-mil thick on each side. Cost for this would be only $5.30.

While on the subject of paperboard, we should make mention of the printable, gluable polyethylene-coated board—a product introduced commercially during the past year by Lowe Paper Co. As many of you know, relatively low heat-sealing speeds have plagued the use of polyethylene coated board and paper in folding box production. With the new technique, polyethylene-coated board can now be run on conventional gluing equipment at accepted commercial speeds. This offers paperboard manufacturers a golden opportunity for supplying an improved product to many of their most important customers. Recent tests in our laboratories show the polyethylene coated board has definite superiority over standard laminated constructions with regard to grease and oil permeability. And, unlike waxed board, creased polyethylene coated board offers excellent moisture protection—virtually on a par with that of a film liner.

One likely market for such a coating would be frozen foods. The economy of a polyethylene-coated board here could be an important consideration. Supported by a printable polyethylene coating, only a single wall box is needed—no liner or overwrap. Also, loss of product protection due to creasing of the wax wrap could be eliminated. Creasing has virtually no effect on a polyethylene coated carton.

The need for protection of sugar-coated cereal foods is well documented. Moisture pickup or loss is a hazard of shelf storage. In laboratory tests simulating typical storage conditions, sugar coated cereal packed in a high-density polyethylene-paper box "kept" better than that packed in the presently used commercial package, which is a liner bag made of foil/pouch paper/wax laminate, in a carton.

Improved performance of glassine paper has been achieved by coating it with polyethylene instead of wax. The water vapor transmission of 25 lb. waxed glassine (4 lb. wax) is reported to be 0.20 to 0.40 g. per 100 sq. in. However, when creased, the permeability rate jumps from 2.0 to 5.0 g. A 1-mil coating of high-density polyethylene would run 0.30 to 0.48, but these ratings do not change with creasing or flexing. The important thing here, of course, is the addition of flexibility to the packaging material, an edge which could enable paper to get a firmer grip on some of its traditional markets—markets which are being eyed by cellophane, aluminum foil, and plastic film manufacturers.

Now, let's look at a few examples which lend support to the second part of the statement we made awhile back—"penetrating markets where use of paper is small or virtually nonexistent."

Multiwall bags are again a good case in point. Less than one fifth of the paper shipping bags produced go into uses requiring moisture protection. The great majority of products requiring moisture protection are being shipped in nonpaper containers. The MVT properties of high-density polyethylene coated paper rate right up there with these competitive materials—and it costs less!

The ethical drug field is another industry vitally interested in the kind of improved, low-cost packaging that polyethylene-coated paper and paperboard offers. For example, the common aspirin tablet is put in a glass bottle, labled front and back and given a screw-cap closure. The bottle goes into a paper carton with a stuffer. The result: a highly respected, highly effective package.

But as time, progress and rising material costs swallow

more of the profit on such drugs as aspirin tablets, there is new interest in cost reducing packages. And this interest leads to the possibility of new concepts of packaging in fields even where tradition is strong. There is interest in eliminating the glass bottle in packaging aspirin and similar tablets. A single wall box with a suitable coating of polyethylene to provide adequate moisture protection is a definite possibility. Such a box offers plenty of room for original design—perhaps a flip top, or a pour spout, to minimize the problem of opening, dispensing, and storage.

Another promising use of polyethylene-coated board—high-density in particular—is in the construction of carrying cases for the produce industry and the brewing and bottling industry. Due to the hard surface and excellent abrasion resistance of high-density polyethylene, this lightweight case could withstand multitrip abuse—and could be readily washed clean.

One more area where paper might replace a nonpaper product—in this case fabric—would be in automotive constructions. Polyethylene-coated paper could definitely be considered a candidate for use in door panel, head liner, and rear deck liner constructions. The rising cost of fabric increases the potential for paper material. Polyethylene-paper combinations naturally have a big price advantage over fabric, and product improvement is very likely. High-density polyethylene-paper constructions would provide excellent abrasion resistance—top protection against scuffing and snagging.

Perhaps the most vulnerable of nonpaper packaging materials is metal—consumer-type cans particularly. Price here is a key consideration. As steel prices continue upwards, can prices continue upwards as well. If certain can users could be convinced that they will get suitable product protection at lower cost by using paper-plastic combinations, a big boost would be given to paper business.

What are the most vulnerable of can markets? A recent market study indicated that vegetables and juices, dairy products, coffee, and lard and shortening are high on the "most likely" list. These four markets account for some 19 billion packaging units annually—close to 40% of the consumer-type metal cans being shipped. Whether paper with the aid of a polyethylene coating can gain ground in any of these can markets may ultimately depend on your ingenuity.

In fact, it is only through the combined ingenuity of paper and plastics people that polyethylene-coated paper can possibly realize the market potential which seems to exist for it. In things like the vulnerable can markets, the aspirin box, the fabric replacement—the application of polyethylene-coated paper has extremely practical advantages. What then is needed to turn potential into actual sales?

You'll recall that I opened this talk with a quote from a publication. I'd like to answer that "what's needed" question with another quote. At a meeting of the Fiber Box Association last fall, a leading paper industry executive said that—

> "Industry production had increased an average of 7.4% a year until 1955, but had been standing still since. Box makers . . . had lost about 330 million dollars in sales because of the decline in growth . . . Manufacturers would have to increase the quality of their product, develop new uses and be more alert to competition from rival forms of packaging."

To give you a rough idea of the kind of profits which might be possible through use of polyethylene extrusion coatings, I cite the following example. A ton of 50 lb. kraft paper sells for about $180 to 190. With an additional $270 investment of 15 lb. per ream of high-density polyethylene, this same ton of kraft paper sells for $720. Even after allowing a reasonable factor for labor, scrap loss, and other expenses, this is an attractive markup.

There is little question that you as an industry today face a formidable challenge—a challenge to create better products in order to achieve better profits. It is our firm belief that polyethylene coated on paper is precisely this kind of "profit-making" product—one that can compete on an equal footing or better with other materials in a wide variety of important end use markets.

Presented at the meeting of the Empire State Section of TAPPI held at Lake Placid, N. Y., June 11–13, 1959.

A Study of the Chemical Balance of Flotation Savealls

Charles H. Mayhood, Jr.

The basic principle underlying the use of savealls is conservation of materials. Until recent years, this conservation was applied strictly to furnish components within the paper mill system. The installation of a saveall depended upon the economic worth of the materials being lost versus the installation and operation costs of the recovery unit.

As the costs of papermaking fibers and fillers increased, greater rates of recovery were economically justified. This rising cost of materials coupled with even faster rising costs of manpower and equipment have made highly efficient recovery of materials imperative to competitive papermaking operations.

In additions to the economics of furnish component recovery, another factor is becoming more significant. Increased emphasis on paper quality, especially brightness, has demanded partial or complete water treatment systems to supply the paper mill with dirt-free and color-free water. Supplying water which meets these specifications has become a substantial cost factor. Closing of white water systems has been most helpful in reducing the amount of water needed. However, in many cases fresh water still must be used for showers since macine white water usually causes plugging and results in down time.

The saveall can make another contribution, that of providing reusable clarified water to replace fresh water systems on the paper machine and in stock preparation operations.

Generally speaking, the economics of papermaking do not justify complete recovery of solids and white water. The effluents of paper mills are still sizable in solids content and volume, about $^1/_2$ lb. per 1000 gal. at a rate of approximately 1 million gal. per 50 tons of paper produced.

Today we are faced with a problem which has no specific relation to improved mill economy. It is conservation of another kind; conservation of our natural resources, namely, the streams adjacent to our mills. Although the $^1/_2$ lb. per 1000 gal. at the effluent rate referred to seems like a small amount of those inside the mill, it represents a potential source of contamination to the stream.

Since the situation is one of compliance with New York State Stream Standards, our economics of recovery must be based on those requirements. One-half pound per thousand gallons effluent represents 60 p.p.m. of filterable solids being introduced to the stream before dilution. The regulations indicate that there should be no appreciable increase of settleable solids in the receiving stream after opportunity for reasonable dilution. The total allowable solids content of mill effluent would depend upon the volume of the effluent and the flow characteristics of the stream.

DISCUSSION AND RESULTS

There are three basic types of recovery units which may be used, dependent upon the amount of white water to be treated and the space available for installation.

The mechanical or filter-type saveall will handle the most white water with the least amount of space. Some manufacturers of this equipment guarantee a maximum effluent solids

Charles H. Mayhood, Jr., Chemical Engineer, Central Technical Dept., St. Regis Paper Co., Deferiet, N. Y.

content of $^1/_2$ lb. per 1000 gal., with as low as $^1/_4$ lb. per 1000 gal. normally possible.

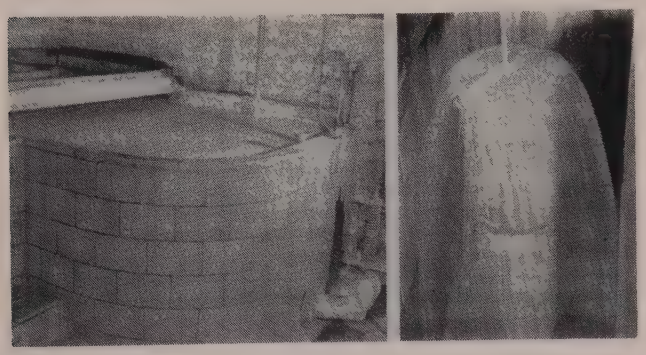

Fig. 1

The flotation saveall requires more space per rate of influent than does the mechanical type, but can produce effluents which run as low as 0.1 of a pound or less of filterable solids per thousand gallons. These savealls are much more sensitive to changes in flow and chemical concentration than are the mechanical type and, when upset, produce effluents with filterable solids contents above $^1/_2$ lb. per 1000 gal.

Perhaps the best recovery unit is the clarifier which can handle large volumes and produce effluents virtually free of suspended solids. A major limitation of this unit is space. It probably would be necessary to erect this unit outside the mill if a site were available. Since many paper mills in the northeast are restricted on space, installation of such a unit might be quite expensive. And adverse climatic conditions probably would affect efficient operation of such an installation.

There are two types of flotation savealls, the Adka or Savalla and the Sveen-Pedersen (Fig. 1). This paper will be directed toward the Sveen-Pedersen unit. In principle, the mechanisms of recovery for both types are very similar.

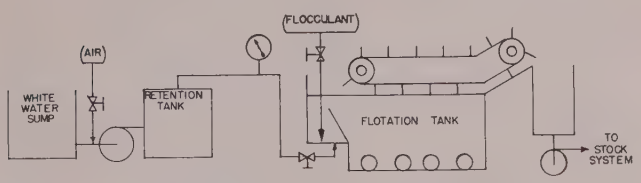

Fig. 2. Flow diagram of the Sveen-Pedersen saveall

In the Sveen-Pedersen system (Fig. 2) white water is pumped from its source into a retention tank for saturation with air, which is admitted through an injector to the white water at the suction side of this pump, about 1% by volume. The retention tank should be large enough to permit a minimum 1-min. holding period for all influent before discharge into the flotation tank. The retention tank can be replaced by a large-diameter pipe of suitable length if the distance from the pump to the flotation tank so permits. The retention pressure, usually 50 to 60 p.s.i.g., is controlled by a valve at the flotation tank inlet. A flocculant is introduced into the flotation tank at this point. As the white water, supersaturated with air, is introduced into the tank, the flocculation of solid particles and released air bubbles takes place. The floc rises to the surface, is skimmed off, and returned to the stock system. The clarified effluent is drawn off at the bottom through standpipes and pumped to the machine system. Any excess overflows to the sewer.

The operation of the Savalla differs only in the method of flotation. The white water is saturated with air at atmospheric conditions, then is introduced into a flotation tank under vacuum where the air is released to cause flotation. The floc floats over a dam and the effluent discharges through a water leg.

The circumstances which cause flotation savealls to upset usually can be controlled if the unit is designed for the proper capacity and influent solids content. If the unit is too small for the volume of white water, excessive turbulence will break up the floc and recovery will be unsatisfactory.

In essence, the mechanism of flotation savealls is the separation of solids from the white water by flocculation and subsequent attachment of released air bubbles resulting in a suspended floc.

This brings us to the theoretical aspects of flocculation. Easton and Baum (*1*) state, "In aqueous systems, fibers are negatively electrostatic either by ionization of positive ions from their surface groups or by sorption of negative ions." This statement also may be applied to fillers. The fibrous portion of the solids are chiefly cellulose and exhibit properties in reactions analogous to colloid gels.

Because the electrostatic potentials of the solids are of like charge, the particles repel one another and remain in dispersion. In order for these particles to become agglomerated, the repulsion forces must be removed.

The point at which the particles will exhibit a lack of electrostatic charge is called the isoelectric point. This point is defined as the pH value of its solution in which the suspended material will not migrate in an electric field. At this point, the capacities of the materials to react are at a minimum and they exhibit the greatest flocculation tendency.

Alum addition is one means by which this isoelectric condition is reached. When alum is dissovled in the system, the white water is loaded with a positive electrostatic potential. As the pH is reduced, the isoelectric point is approached.

The isoelectric condition can be overrun with too much alum. Excessive alum causes sorption of positive ions by the particles. Then the particles again exhibit electrostatic potentials of like charge, repel one another, and produce a stable dispersion.

At the optimum condition, a colloidally active coagulant is admixed into the solution and the particles are agglomerated. In the flotation process, air bubbles contact and attach themselves to the agglomerated particles.

In practice, description of the isoelectric point by pH is virtually impossible. The pH at this point will vary from mill to mill depending upon the acidity or alkalinity of its raw water which may alter the alum solubility or cause formation of aluminum hydroxide.

Studies by Brecht and Scheufelen (*2*) show that the isoelectric point is affected by the degree of rosin sizing in the papermaking furnish. They found that optimum flocculation occurred at lower pH's during manufacture of sized grades. It is postulated that some of the aluminum ion was combined with the sizing resin and had to be replaced with additional alum. They concluded that pH was not a comprehensive guide to flocculation efficiency.

Work by Clodfelter (*3*) on several Sveen-Pedersen savealls showed that peak efficiencies were reached at approximately 12 to 15 p.p.m. alumina (Al_2O_3) concentration.

From this background of information, it became apparent that pH can describe optimum flocculation conditions only at a given set of papermaking conditions.

A study was made on one Sveen-Pedersen saveall treating white water from coating rawstock manufacture. The observation period covered 15 days. To make the study over a period of several days where changes in furnish and additives would be encountered, the measure of alumina concentration was used to indicate the flocculation condition. Operational data such as air flow to white water, retention pressure, and feed rate of flocculant were recorded. The saveall appeared to be handling volumes of white water equal

to or slightly in excess of its capacity. Samples of saveall influent and effluent were taken once a day and analyzed for solids, ash as a per cent of solids, influent temperature, pH, total acidity, and alumina concentration.

Many variables were eliminated since operating procedures at the saveall were relatively constant throughout the test period. Furnish changes were negligible. It was assumed that the variations in the saveall efficiency during this period were caused primarily by chemical variations in the white water.

The data were subjected to correlation analyses which indicated the trends that existed within the system during the test period.

The influent pH during this period averaged 4.3 and ranged between 3.9 and 4.8. The saveall efficiency averaged 90% and ranged between 86 and 94%.

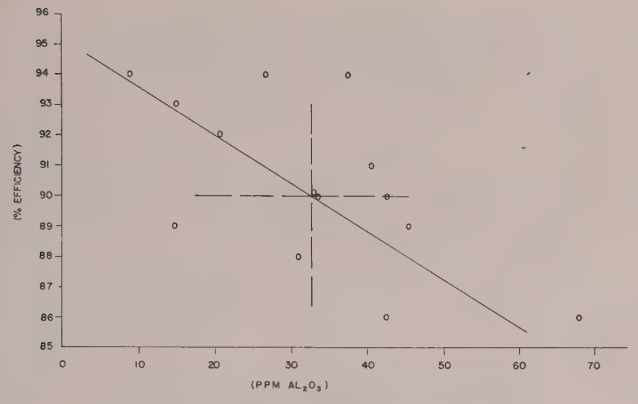

Fig. 3. Efficiency versus Al_2O_3 concentration; confidence limit = 98%. r = 0.6255

From correlation studies, it was found that the saveall efficiency increased as the alumina concentration decreased (Fig. 3). A corresponding correlation was evident between efficiency and total acidity (Fig. 4). The coefficient of correlation of efficiency with pH showed that efficiency increased as pH increased (Fig. 5).

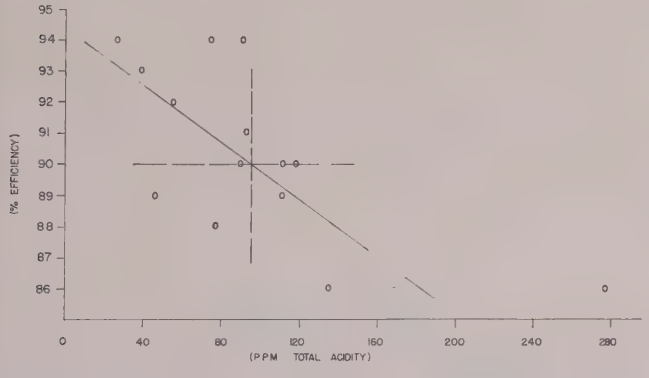

Fig. 4. Efficiency versus Total Acidity; confidence limit = 99%. r = −0.6686

Re-examination of the test data showed that, in general, the best efficiencies were obtained at the lowest alumina concentrations and at the highest pH levels.

It was evident from the inverse correlations of efficiency with total acidity and alumina that the optimum flocculation condition had been overrun with excessive alum. Therefore, it was recommended that the pH, since it was normally used as a guide by the mill personnel, be raised to a range between 4.5 and 4.8, which, for this particular system, would be comparable to an alumina concentration in the range of 10 to 15 p.p.m.

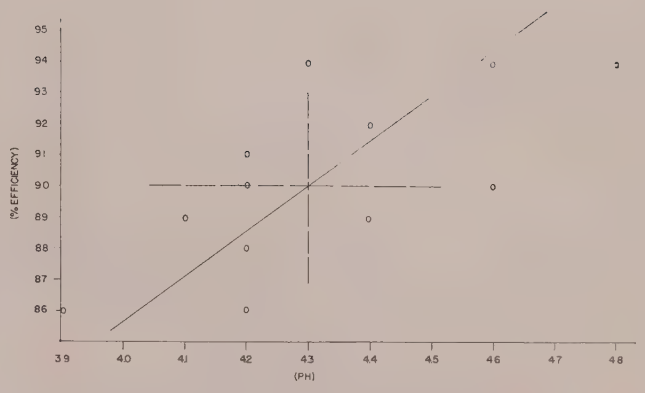

Fig. 5. Efficiency versus pH; confidence limit = 99%. r = +0.7186

Similar operational practice to that recommended was noted at another mill running groundwood publication grades. Their Sveen-Pedersen saveall recovery efficiencies were usually 97% or better. One of the primary procedures applied in stabilizing an upset saveall was a reduction of the amount of alum in the furnish.

Although establishment of the optimum chemical balance of flotation savealls requires critical control and efforts to accomplish highest solids recovery, this will carry over in effecting a better chemical balance throughout the rest of the paper machine system. Dispersion and flocculation of the furnish on the wire is analogous to the agglomeration of particles in the saveall.

Using this analogy, good formation, a source of concern to the papermaker, may be improved indirectly by maintaining optimum recovery efficiencies at the flotation saveall.

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An Empire State Award paper presented at a meeting of the Northern District, Empire State Section of TAPPI held in Watertown, N. Y., April 9, 1959, and at the meeting of the Empire State Section of TAPPI held in Lake Placid, N. Y., June 11–13, 1959.

Indiana District officers for 1959–60: Thomas F. Sullivan (Hartford City Paper Co.) treasurer; W. Doyle Boggess (The Beveridge Paper Co.) vice-chairman-programing; John S. Sullivan (Monsanto Chemical Co.) vice-chairman-membership; Charles E. Eberly (Paper Art Co.) chairman; Harris O. Ware (The Beveridge Paper Co.) Executive Committee; W. B. Lincoln, Jr. (Inland Container Corp.) Executive Committee; and Cushing B. Roth (Morningstar-Paisley) secretary

LETTERS TO THE EDITOR

British Tax Deduction

Editor's Note: The following letter was received from a TAPPI member in the United Kingdom with the request that it be published for the benefit of other members who may not be acquainted with this ruling of the Commissioners of Inland Revenue.

INLAND REVENUE
Chief Inspector of Taxes Branch
New Wing Somerset House, London W.C.2
Telephone: TEMple Bar 2407, Ext. 760
22 May, 1959.

Dear Sir:

I have to inform you that the Commissioners of Inland Revenue have approved *The Technical Association of the Pulp & Paper Industry* for the purposes of Section 16, Finance Act, 1958, and that the whole of the annual subscription paid by a member who qualifies for relief under that Section will be allowable as a deduction from his emoluments assessable to income tax under Schedule E. If any material relevant change in the circumstances of the society should occur in the future you are requested to notify this office.

I should be glad if you would inform your members as soon as possible of the approval of the society. The circumstances and manner in which they may make claims to income tax relief are described in the following paragraphs, the substance of which you may care to pass on to your members.

Commencing with the year to 5 April 1959, a member who is assessable to income tax under Schedule E in respect of the emoluments of an office or employment is entitled to a deduction from those emoluments of the whole of the annual subscription which is due and payable by him to the society in the income tax year provided that:

(a) the subscription is defrayed out of the emoluments of the office or employment, *and*,
(b) the activities of the society so far as they are directed to all or any of the following objects:
(i) the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar postions);
(ii) the maintenance or improvement of standards of conduct and competence among the members of any profession;
(iii) the indemnification or protection of members of any profession against claims in respect of liabilities incurred by them in the exercise of their profession;

are relevant to the office or employment, that is to say, the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned.

A member of the society who is entitled to the relief should apply to his tax office as soon as possible for form P358 on which to make a claim for the relief due to him.

Yours faithfully,
W. WAHNE
Senior Principal Inspector of Taxes
The Secretary-Treasurer, The Technical Association of the Pulp & Paper Industry

14th Engineering Conference
Hotel Penn Sheraton, Pittsburgh, Pa.
Oct. 11–15, 1959

EMPLOYMENT SERVICE

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Requires degree in mechanical engineering with or without experience. Age to 30.

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Requires degree in mechanical engineering and experience in the machinery field or the paper industry. Age to 35. These positions require versatility, creativity, and a high degree of mechanical ability to do responsible project engineering work. Working field: Paper converting and finishing machinery. Willingness to travel between plants is essential. Salaries open.

Send complete résumé in confidence to:

Research Director

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COVINGTON, VIRGINIA

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Paper Technology, Chemistry or Chemical Engineering background is preferred.

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P884-59. Graduate chemist, chemical engineer, or paper school graduate for development work in technical department of integrated midwestern paperboard operation. 2 to 3 years experience in paperboard or related industries required, preferably in coatings. Excellent work situation and advancement opportunities. Salary open. Submit detailed résumé to Personnel Director, The Ohio Boxboard Company, Rittman, Ohio.

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Columbia Cellulose Company, Limited,
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6711

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